THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 62 Thursday, June 27, 1940 No. 1245

PUBLISHED WEEKLY

Subscription Terms: 17s. 6d. per annum.
Foreign and Colonial: 20s. per annum.
All Subscriptions are payable in advance.

THE FOUNDRY TRADE JOURNAL
49, Wellington Street, London, W.C.2.

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The Welsh Engineers' and Founders' Association
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Filling in Forms

It is recognised in Government circles that the constant requests for more and more statistics are a real source of aggravation to busy executives, as they impose an additional burden on their working time. It is well known that the better the internal organisation of a foundry, the less onerous is the task of extracting figures, and despite the spate of form-filling we find some foundries have been so impressed as to the utility of the figures derived that they are pursuing a course of additional analysis for the better organisation of their own works. Thus for each type of machine they make, a list of foundry components is compiled in the first column of a comprehensive schedule. The following data are also compiled:—The weight of each component, both as cast and as fettled; the number of each component required for a given type of machine; the grade of metal which is to be used; the number of the cores required; the type of moulding machine which must be used for its production; the weight of any grids or core irons used; the pattern or pattern-plate number; finally, there is a column for "remarks." Presumably this would be useful for noting whether any special conditions have to be observed for core drying, alloying, casting temperature, the runners and risers to be used, and so forth.

Once such a schedule is filled in, conditions are then instituted for relieving the chief foundry executive of much detailed questioning when a component comes back into production. Moreover, when a new order is received, its physical analysis becomes a matter of routine and—what is of particular importance—its influence on general shop working becomes immediately apparent. A glance at the schedule will immediately show the pressure being placed on each type of moulding machine. Again, the reaction on the core-shop organisation becomes obvious, whilst the increased or decreased weight of the various mixtures to be melted daily is indicated.

One firm making such a survey had in mind this very question associated with the limitation of mixtures to be used to a minimum. It was found that in many cases a more expensive mixture was being used than was really necessary. We are aware that such a survey as we have indicated does not apply to the jobbing shop, but as quantity production is the order of the day, the system becomes increasingly important. It is only by this method that one can estimate with certainty what additional load on the shop can be taken up with a sure knowledge that existing production will not suffer. It is more than possible that we have omitted some important entries on the schedule, but they will be apparent to practical executives. For instance, in some shops it will be desirable to state the quantity of any special alloy to be incorporated. In other cases, information which will govern the conduct of the drying ovens will be set down, as this factor may be a limiting one for certain types of output. In other cases, a statement as to how each casting is to be fettled will reveal useful information, for quite often with a change of production different fettling methods are called for, and usually additional specialised machinery has to be brought into operation.

It is as well to bear in mind that a changeover will render some types of machines idle, yet these machines may be wanted by other firms. Thus steps should be taken to see that they are used, if not in another department of the works, then in a neighbouring concern. A national survey of machines is being made, and this includes foundry machinery. There is yet another form worth filling up and this should detail surplus stocks of useless material. Once it has been filled in, steps should be taken to render the material available to works which can make use of it. Only recently we were instrumental in transferring a large quantity of special bricks which, whilst useless in their place of origin, were well suited to the requirements of another foundry. We are sure that this is not an isolated case, for on occasion we have discovered stocks of special bricks for furnaces no longer being used; materials—often valuable—bought for some special experiment; agglutinants bought by the "last foundry foreman," but not appreciated by the present one (yet if the "last foundry foreman" is still in harness he might like to acquire such stocks). We have even encountered material, the origin and use of which were a mystery! The fundamental principle of such matters is that what is one man's poison is another man's meat. The above is put forward as a contribution to the essential increase in the output of munitions of war, which at the present time is so urgently needed. The filling in of forms can be of real service, not only from the angle of the national assessment of production potentialities, but also from the viewpoint of internal organisation.

Still More Copper

BY "ONLOOKER."

The military debacle in France is likely to have far-reaching and unpredictable repercussions, but already events are crowding thick and fast before the astonished gaze of the whole world. Mr. Churchill has announced in no uncertain voice Great Britain's intention to continue the struggle and to this end it is understood that this country will take over French munitions commitments in the United States. This action must be presumed to cover the very considerable tonnage of copper which the French Government had contracted to purchase from American producers, but the total extent of this obligation is not known.

If the supposition be correct, it must mean a very marked augmentation of the tonnage of copper available in the United Kingdom, for it is common knowledge that immense quantities are all the time coming forward from Empire sources, where production has been geared up to meet the augmented wartime demand. It is true that early in June it was announced that the Ministry of Supply had decided to make large purchases of electro wire bars in the United States, the price mentioned being 11.37½ cents f.a.s., but there was no suggestion of a permanent departure from the principle of confining our purchases to the sterling group.

Katanga Copper for Refining

Since the overrunning of Belgium the refinery at Hoboken has been in the hands of the enemy, but it is doubtful whether more than a modest tonnage of copper fell into German hands as a result of the invasion. The Katanga copper now comes within the orbit of the sterling *bloc* as the Belgian franc is linked to the pound, and this should make it possible for the Ministry of Supply, if they so desire, to arrange purchases of this brand from now onwards. Since the outbreak of the war a good proportion of the Katanga blister has crossed the Atlantic to the States for refining, the resultant electro returning to Europe for use in the manufacture of munitions. In the ordinary way France used to take a large proportion of what was refined at Hoboken but now the electro will come to Britain—if we want it.

In connection with Empire supplies of copper we must not forget that the Dominions have their contribution to make—and it is an ever-growing contribution—to the grand total of munitions, and for this they must have the necessary raw materials. Australia and Canada are both producers of copper and they are both facing up to turning out all the material they can, but for this metals are wanted and so their own factories come first, for obviously it would be folly to ship away anything that is wanted on the spot.

Unprecedented Consumption

As far as this country is concerned, statistical information is a thing of the past and it is certainly not worth indulging in guesswork. All that one can say with some assurance is that the production of munitions of war which require copper for their fabrication is on a gigantic scale and is likely to get bigger as the months go by. It seems quite certain, too, that the copper consumption figures of this war dwarf those of the conflict twenty-five years ago and consumption is likely to break all records. In this great gathering together of copper, scrap will play its part, and there is every expectation that the yield will be considerable as time goes on and more and more secondary copper from the wartime manfacturing system becomes available for re-use. This is an aspect of the matter which undoubtedly calls for the most careful consideration by the Ministry of Supply through its specially qualified officials.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Desulphurising Pig-iron

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—We note in your issue of June 13 an abstract of the Paper read by Mr. H. A. Brassert before the Eastern States and Chicago District Coke Oven and Blast Furnace Association at Cleveland on "Recent Developments in the Iron and Steel Industry of European Countries."

In this abstract it states that the desulphurising mixture used consists of burnt lime, soda ash and fluorspar. While such a mixture was used in the early stages of development of desulphurisation, we should like your readers to know that better results have been obtained by the substitution of raw limestone, of suitable size, to replace the burnt lime previously used in the mixture. This replacement by limestone not only reduces the cost of the mixture but also improves the efficiency of the desulphurising action.—Yours, etc.,

J. MILES,
(Managing Director,
H. A. Brassert & Company, Limited).

Granite House, Cannon Street,
London, E.C.4.

June 20, 1940.

TO MEMBERS OF THE INSTITUTE OF BRITISH FOUNDRYMEN

It is the earnest desire of the President and Council that members should discuss in writing the various Papers which were prepared for presentation at the abandoned Cheltenham Conference. It is a courtesy and an act of appreciation they owe to the authors. Your comments should be sent to Mr. John Bolton, St. John Street Chambers, Deansgate, Manchester, 3.

Company Meetings

Scottish Machine Tool Corporation, Limited

The annual meeting of the Scottish Machine Tool Corporation, Limited, was held in Glasgow last week. SIR HARRY GREER, who presided, in reviewing the accounts, pointed out that although the past financial year contained seven months of the war period, during which the works had been almost wholly engaged upon war orders, the earnings were substantially lower than in the previous year, when commercial work constituted the great bulk of the output. The order-book of the Corporation, the chairman stated, was extremely full at present.

Consett Iron Company, Limited

Pointing out that the steel industry had from the commencement of the war been under Government control, MR. CLIVE COOKSON, presiding at the annual meeting of the Consett Iron Company, Limited, said that the directors had readily co-operated with the Minister of Supply by holding at the country's disposal the whole of their resources and organisation and by planning their programme in such a manner as to ensure the most efficient help in the successful prosecution of the war. Further, in collaboration with their employees in the steel departments of the company, effect had been given to the recent appeal of the Minister of Labour to obtain maximum production, and they were now working the fullest number of shifts for which material was available. To meet anti-glare requirements, a machine for the mechanical casting of pig-iron (thus dispensing with the sand beds and resultant glare when casting) was at present being erected and should be in operation early in August.

Random Shots

In the conflicting emotions of a complicated life, one sometimes hardly knows whether to laugh or to cry when some particular event happens. The very formidable and comprehensive list of goods to be controlled and restricted by the Government produces much the same effect. Whilst one weeps at the situation that has caused such a list to be made, the very cataloguing of its scores of items contains much unconscious humour.

* * *

First come corsets, brassieres, braces and suspenders. They that control shall now themselves be controlled! But with what wailing and gnashing of teeth is it learned that loud speakers and wireless sets are to be let off scot-free, not to be controlled at all. And in the act of thanking a kind providence (or a conscientious parent) that one still has teeth with which to gnash, it is a relief to learn from a later item in the list that artificial teeth will still be procurable in abundance.

* * *

Although glassware is heavily blue-pencilled, it will still be possible to quaff one's ale in a civilised manner out of a tumbler, for a thoughtful Controller has decided that these shall not be restricted. How long will it be, then, before (because of a shortage of milk bottles) pretty dairy maids will be seen leading cows from door to door to be milked on the very threshold of the consumer?

* * *

A report from Pittsburgh says that the first civilian parashootist legion in the United States has been formed by a gun club at Jeannette, Pa. This may be the first in America, but the Editor tells "Marksman" that his small daughter of the same name formed her own class club some weeks ago. It apparently consisted of a "gang" sworn to help the school in time of need, and they were well armed with toy pistols and ammunition at a ha'penny a strip. This ammunition went off with such a bang that the club soon had to be banned by teachers and parents alike, who were beginning to show signs of shattered nerves.

* * *

A youngster living in a neutral area was asked the other day if her parents had any plans for her in event of air-raids. "Yes," she said, reassuringly, "Mummy says that if she had enough money and I had an Auntie, she'd send me off to Canada, and then she'd train as a nurse."

Evidently that family is pinning its faith on time bombs, with very much delayed action into the bargain.

* * *

Apropos of sending our children to distant parts of the Empire, a Rhodesian journal suggests that they could solve one of England's newly-created problems. It is difficult to know what to do with the lads in that period between leaving school and joining the army. Why not send them out to Rhodesia for a year, or two of farming? One Rhodesian writer is confident that the right type of boy would be worth his keep over there. It is an idea, of course, but would not the same type of boy be worth his keep on a home farm, too?

"MARKSMAN."

Broken Hill Production

Pig-iron production at the Newcastle works of Broken Hill Pty., Limited, and the Port Kembla works of Australian Iron & Steel, Limited, during the last quarter of 1939 totalled 434,837 tons, compared with 305,078 tons for the corresponding period of 1938. Steel-ingot production for the same respective periods was 450,628 tons and 290,814 tons.

Melting of Copper-Base Alloys to Retain Physical Properties*

By W. B. GEORGE

Physical properties are "built" into the different alloys from which castings are made by compounding various metals to meet specific requirements. After an alloy is compounded to meet certain physical requirements, it is often discouraging to find that the intended properties are lowered to such an extent in the foundry manipulation that the castings have to be rejected. Such losses in properties can be attributed to two causes:—(1) Lack of feeding, and (2) gas absorption. Either of them is easily detected by a fracture of the specimen.

If lack of feeding is a cause, the metal will show a localised discoloration in the fracture with a clear outline of crystalline structure. When the fracture shows an even distribution of small holes, with larger ones outcropping in the heavier sections, and an absence of outlined crystals, the metal is definitely gassed. In mild cases of either, where the eye cannot differentiate, a magnifying glass will clear the doubt. As feeding is well understood by foundrymen, only absorption will be discussed.

Causes of Gas Absorption

Gas is absorbed by the bath of metal in the furnace from a reducing atmosphere and is liberated within the casting in inverse proportion to its solidification rate. There is no cure-all for this gassed metal condition regardless of the type of furnace used. Gas, oil, coke or indirect-arc electric furnaces—all will produce gassed metal, if not properly operated. This gas absorption is governed by three invisible dimensions: temperature, furnace atmosphere, and time.

Means for measuring these three dimensions are not as simple as the length, breadth and depth used by the rest of the plant. Due to this fact, melting is least understood and, when properties fail, the blame is passed back and forth until it often reaches the supplier of raw materials. Numerous foundries refuse to take on work demanding that physical properties be met and openly admit it is beyond their control to do so.

Melting Units for Copper-Base Alloys

There are many media employed in melting copper-base alloys, and practice varies from plant to plant. The author will endeavour to include the media with which he is familiar, and will designate the best general procedure for melting with each type. The equipment to which these recommendations apply consists of the following types:—Oil-fired crucible furnace; gas-fired crucible furnace; oil-fired open-flame furnace; gas-fired open-flame furnace; coke-fired natural-draft crucible; coke-fired forced-draft crucible; and indirect-arc electric. Before a thorough understanding of this subject can be achieved, it will be necessary for each foundry to make a study of its particular plant.

General Melting Practice

In an efficiently operating furnace, metal has a liberal leeway and some shops function without even such essential equipment as pyrometers. In many of these cases, it is more by good fortune than knowledge that production results are satisfactory, for somewhere along the line a good furnace designer was involved.

All equipment does not possess these redeeming features, and it is necessary to plot charts to determine where the weakness lies. The author has used a graphic method to chart the operation of existing equipment and has been able to clear up gas conditions by either a revamping of the equipment or by establishing a stabilised melting practice. Where furnace help has not been fully competent, at times, it has been necessary to insist upon both.

Fig. 1 illustrates the method applied to an installation of No. 80 oil-fired crucible furnaces, melting 85-5-5-5 brass alloy. The dotted line shows the limit control that was used to keep gassed metal from being poured into the castings. The tensile strength and gas pick-up have a direct relation to each other, and the dotted line in Fig. 1 can be established by fractures.

Data for such a chart are compiled by taking the most difficult alloy (in most shops it is the 88-10-2) and pouring test-bars from a single melt, casting them from low to high temperatures, and keeping a note of time, temperature and atmosphere. As the reducing side is where gas pick-up is obtained, the melting zone must be kept reducing during the test. However, in actual practice, an oxidising atmosphere can be used, with a far wider range of insurance.

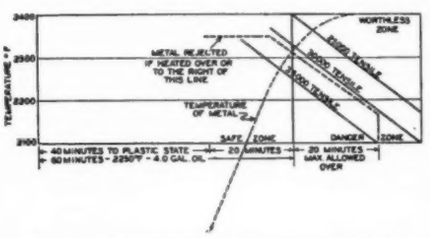

FIG 1.—PERFORMANCE CHART FOR NO. 80 CRUCIBLE OIL-FIRED FURNACE MELTING 85-5-5-5 RED BRASS.

Conditions of Furnace Atmosphere

It is easy to tell whether an atmosphere is reducing or oxidising by the following methods:

(1) On oil- or gas-fired equipment, pass a piece of zinc through the flame. Should it come out black, a highly reducing condition exists. If the zinc becomes straw yellow to light grey, the atmosphere is slightly reducing, and if the zinc remains as clear as when inserted, it is oxidising.

(2) On coke pit furnaces, if the crucible top sets below the flue opening, it is safe to assume that the atmosphere over the metal is reducing. This can be further checked by skimming back the charcoal and noting whether or not an oxide film follows the skimmer. If it does so, the atmosphere over the metal is oxidising.

(3) On electric (indirect-arc) furnaces, if the electrodes burn nearly square, the atmosphere in the furnace is reducing. When an oxidising atmosphere exists, the electrodes burn into long tapers with a heavier electrode consumption. A little practice in checking this point will enable the melter to do a much better job.

Fuel Consumption

Good melting practice will consume the amounts of fuel or current for each 100 lbs. of metal melted, after the furnace is once hot, as shown in Table I. This does not mean that good metal will not be obtained if additional fuel is used. However, the equipment most likely will bear checking, as this may indicate a potential source of trouble. It should be noted that, where charges are less than 200 lbs., no figures of economy have been established.

TABLE I.—*Fuel Consumption per 100 lbs. of Metal Melted.*

Type of furnace.	Fuel.	Consumption.
Stationary crucible	Oil	2 gal.
	Gas	320,000 B.T.U.
Tilting crucible	Oil	1.6 gal.
	Gas	300,000 B.T.U.
Open flame	Oil	1.4 gal.
	Gas	280,000 B.T.U.
Pit, natural draft	Coke	25 lb.
Indirect-arc	Electricity	15 kw.-hr.

Melting Time

A universal standard of good melting time is given in Table II. In a good oil or gas-fired furnace, it requires two-thirds of the total time to bring the metal to the full plastic state and the remaining one-third to raise it to the pouring stage. In crucible equipment, the maximum temperature of the furnace side wall must be 1,140 deg. C. to maintain the ratio. On open-flame furnaces, 1,125 deg. C. is sufficient.

TABLE II.—*Melting Times for Various Types of Melting Furnaces.*

Type of Furnace.	Fuel.	Charge. Lbs.	Proper melting time. Min.
No. 80 crucible	Oil or gas	240	60 or less.
No. 70 crucible		210	50 or less.
No. 60 crucible		180	40 or less.
Open flame	Oil or gas	1,000	60 or less.
		2,000	90 or less.
Pit	Coke	All sizes	60 to 90 (forced draft).
			120 to 180 (natural draft).
Electric, indirect-arc	Electricity	300	20.
		500	30.

Where the maximum temperature of the furnace side wall is low, the ratios drop considerably, with a loss of fuel and poorer metal.

The information given will be sufficient for a check, and the foundryman can call in his equipment builder to make the necessary corrections if desired.

Deoxidisers

On red brasses and tin bronzes, phosphorus often is added both to oxidised and gassed metals to reduce the metal back to the neutral zone. Phosphorus has a two-fold effect: first, it reduces oxides and second, should the metal be gassed, there is, to some extent, a liberation of the absorbed gas content. Other deoxidisers and degasifiers are made for this same purpose. Some leave a residual balance which is harmful.

To cover this subject of deoxidation and degasification further would be leading the reader to believe that he could cure his troubles in this manner. However, such is not always the case. Fig. 2 illustrates the reaction of phosphorus in either an oxidised or reduced bath of metal.

TABLE III.—*Deoxidisers and the Relative Amounts of Oxygen They Will Eliminate.*

Element.	Ozs. of oxygen 1 oz. of element will eliminate.
Boron	2.21
Phosphorus	1.29
Silicon	1.14
Aluminium	0.889
Magnesium	0.658
Calcium	0.400
Manganese	0.291
Zinc	0.243

In addition to phosphorus, the elements shown in Table III can be used as deoxidisers in various alloys. The effectiveness of de-

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* Paper read at the Chicago Convention of American Foundrymen's Association. The author is associated with R. Lavin & Sons, of Chicago, Ill.

oxidisers is best just before tapping the heat. Each has value and is generally alloyed in various proportions and sold on analysis, or in compounds, to accomplish certain results. There is no set amount of phosphorus or other elements that should be used. The amount

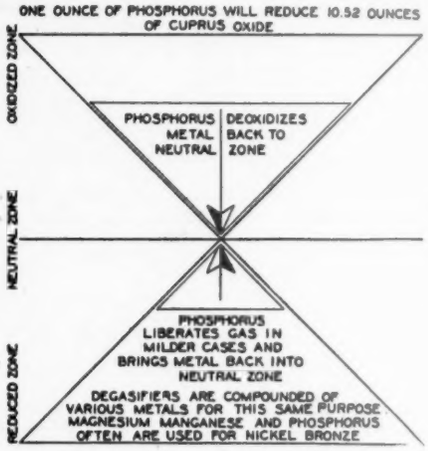
ONE OUNCE OF PHOSPHORUS WILL REDUCE 10.52 OUNCES OF CUPRUS OXIDE
OXIDIZED ZONE
PHOSPHORUS METAL NEUTRAL
DEOXIDIZES BACK TO ZONE
NEUTRAL ZONE
PHOSPHORUS LIBERATES GAS IN MILDER CASES AND BRINGS METAL BACK INTO NEUTRAL ZONE
REDUCED ZONE
DEGASIFIERS ARE COMPOUNDED OF VARIOUS METALS FOR THIS SAME PURPOSE MAGNESIUM MANGANESE AND PHOSPHORUS OFTEN ARE USED FOR NICKEL BRONZE

FIG. 2.—GRAPHIC REPRESENTATION OF THE RELATIVE EFFECT OF PHOSPHORUS IN OXIDISED AND REDUCED METAL.

can only be determined by final analysis of the casting and the residual amounts of the various elements that are permissible.

Table IV lists some popular alloys and the

TABLE IV.—*Amounts of 15 per cent. Phosphor-Copper Used to Deoxidise Various Copper-Base Alloys.*

Percentage composition of alloys melted.				Amount of 15 per cent. phosphor-copper added, Ozs.
Copper.	Tin.	Lead.	Zinc.	
90	10	0	0	4
88	10	0	2	2
88	8	0	4	1½
85	5	5	5	1½
81	3	6	10	1
80	10	10	0	4

amount of 15 per cent. phosphor-copper that is being used for every 100 lbs. of metal.

Checking Metal for Gas

After the alloy is melted and brought up to desired casting temperature, it will be found to be either oxidised or gassed, in proportion to the length of time it remained in the particular atmosphere in the furnace. The alloy can be checked for gas pick-up before pouring into the mould. To do so, punch a 1½-in. dia. sprue cutter into the corner of a mould and pour the cavity ½ in. short of the top. Scrutinise carefully for a few seconds to note the manner in which the metal sets. If a good shrink sets in, the metal is satisfactory. However, if the test piece bulges on the top, it is gassed. Should strings form on the pouring lip and black specks rise to the surface of the bath, the metal is highly oxidised.

While it is conceded that an oxidising atmosphere is desirable, most plants melt under slightly reducing atmospheres, since metal losses are lessened, burners are more easily adjusted, and melting is rapid. An oxidising atmosphere is hard to maintain with any degree of accuracy by manual control.

Melting Procedures for Various Types of Furnaces

The different phases of melting procedure for the equipment mentioned are outlined below.

Compounding Alloys

If a foundry mixes its own alloys, these recommendations should be incorporated in its practice. Heat the copper to its plastic state, then add zinc, lead and tin in the order mentioned. When copper and tin only are used, melt the copper first, then add 2 ozs. of 15 per cent. phosphor-copper shot for each 100 lbs. of melt 5 min. before the tin is added. This prevents the tin from oxidising. In making nickel bronze, melt the copper and nickel together, as they will go into solution and need not heat up to the melting point of nickel.

Natural-Draft and Forced-Draft Coke-Fired Furnaces

Heat the crucible in the furnace until red hot. Use enough coarse charcoal, which will reduce oxides, to cover the bottom. Then charge the ingot or heavy material and continue charging into the crucible until it is filled, never allowing the alloy to get above the plastic stage. Then superheat to pouring temperature. Do not heat the metal more than 55 deg. C. above the temperature at which the metal is to be poured, and do not hold the melt in the furnace after it reaches the desired temperature.

Gas and Oil-Fired Crucible Furnaces

Heat the crucible until red hot. Then place ½ lb. of glass per 100 lbs. of metal on the bottom to create slag. Slag of this type will pick up oxides as well as cover the metal. Weigh out the total charge to be melted and place as much in the crucible as possible. The remainder should be placed on top of the furnace to be pre-heated, and charged into the crucible as fast as the pot will receive it. Do not let the metal get above the plastic range at any time until the crucible is filled, and then superheat for pouring. It will be necessary to skim the slag from the top of the melt when the crucible is poured before adding any deoxidiser.

Do not heat the alloy more than 55 deg. C. above the temperature at which the metal is to be cast; or let it stand or soak in the furnace once this temperature has been reached. Metal cannot be heated to a high temperature, then cooled down, as some of the gas absorbed in melting still will be entrapped and remain in the casting.

Electric Indirect-Arc Furnaces

Preheat the lining until red hot before charging. Do not heat the metal more than 55 deg. C. above the temperature needed to cast it, and do not hold the metal in the furnace until it is necessary to reheat it if sound work is to be expected. The pouring hole of the furnace must be kept of the proper size to keep the electrodes from charging the bath with carbon-monoxide gas. The alloy must be tapped from the furnace when the proper temperature is reached. Care must be exercised in charging gates over the electrodes, for the sand that comes into the zone of the arc will be reduced to silicon.

Open-Flame Furnaces Where Products of Combustion Come in Direct Contact with the Metal

Heat the furnace until red hot, then put in ½ lb. of glass for each 100 lbs. of metal to be charged. Place the entire charge, if possible, within the furnace and melt. If the entire heat cannot be charged at once, do not bring the bath in the furnace above the plastic range until the entire charge is in the furnace. Do not heat the metal over 55 deg. C. above the temperature at which it is to be poured, and do not hold the alloy in the furnace after it is ready.

Observations on Melting

Considerable research and worth-while deductions have been advanced on the subject of phenomena observed in melting, and the author will try to correlate them so as to further a better understanding of the cycle taking place in melting an alloy from the stage of a solid

(*Continued at foot of third column.*)

Founders' Forum

CHILL-CASTING GUNMETAL STICKS

Q.—How can slight porosity at the centre of chill-cast 88/10/2 gunmetal sticks be minimised?

A.—Slight porosity at the centre of commercial-quality chill-cast 88/10/2 gunmetal sticks is not uncommon. The trouble can occur with metal of the highest quality and minor modifications to composition are without major effect. It appears that the principal cause of centre porosity is due to shrinkage. In production, the metal in contact with the mould solidifies practically instantaneously and the rapid dissipation of heat causes the metal at the centre to become so sluggish that the downward feeding action is suppressed and metal of sufficient fluidity is not available to close the minute shrinkage cavities formed by the natural contraction of the gunmetal. That this is the probable explanation of the cause is shown by the fact that bronzes containing over 1 per cent. of phosphorus are free from the trouble due to their extreme fluidity and wide freezing range. Attempts, however, to overcome the trouble by increasing the fluidity of gunmetal have not been too successful and probably the best results are obtained by endeavouring to arrange for rapid solidification to take place *throughout the section* by pouring the moulds at a slow speed using the smallest possible metal stream. This is most conveniently obtained by utilising a pouring basin over the chill mould for centralising the metal stream incorporating a jet runner between ¼ and ½ in. dia., according to the size of sticks to be produced. The most serious objection to slow running is that it decreases production, but this can be avoided by using special plumbago pouring basins standardised for the size of sticks being produced. These basins should be designed to hold just the necessary amount of metal to produce each casting, and in pouring it is then only necessary to run down the line of moulds, filling each bush with metal, but without waiting for the mould itself to fill. By adopting this practice pouring is expedited, and the metal is disposed of without serious drop in temperature.

(*Continued from previous column.*)

to a liquid and return. However, it is not to be expected that all will agree on this cycle.

For all practical purposes, let it be said that when the solid metal changes to a liquid, metal gives up its gases and reabsorption takes place upon superheating. It is in this relatively gas-free state, just after liquidation, that a silver sheen appears on the bath. All metals and their alloys exhibit this phenomenon. This sheen can be seen best by pulling back the covering on the bath in a reducing atmosphere.

There is not a melter who has not seen this phenomenon, but only in rare cases has it been connected in the cycle of events. It is in this gas-free state that the best physical properties lie. In well-operated furnaces, this sheen can be prolonged right up to the pouring temperatures. If it should start to disappear before pouring on red brass and tin bronzes, it can be partially restored by additions of phosphorus or zinc.

To explain this phenomenon in another light, gas in metal is held in an unstable state, and the amount that can be held is dependent on the temperature. Any addition of a metal after the furnace is shut off, some having far more effect than others, results in readjustment of the bath and the release of gas. For this reason, the addition of zinc, when a heat is being tapped, is highy recommended where it will replace that which is lost in melting. In alloys where phosphorus or zinc is not permissible, other metals are compounded to liberate the absorbed gases.

Production of Pressure-Resisting and High-Duty Iron Castings

By J. L. FRANCIS, A.M.I.Mech.E.

(*Continued from page* 471.)

Cast-iron Liners

Having now given some idea of the class of castings manufactured, the properties required of them, difficulties to be overcome and the metal practice which gives satisfactory results, some examples of individual castings may be considered. No matter how good the selection of materials, the melting practice and metallurgical control, they are all defeated if the moulds and cores are badly or carelessly made. Moulding skill and experience play a very large part

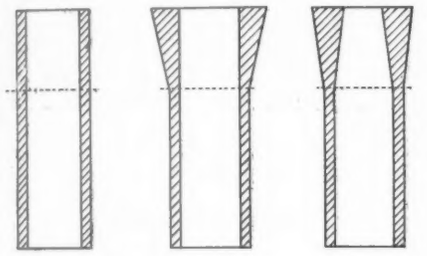

FIG. 1.—HEADERS FOR LINER CASTINGS.

in the successful production of the kind of castings featured here, and much could be written on this aspect alone, if space and time permitted. As it is, the matter can be stressed and then taken for granted, since it is impossible to deal adequately with it in this Paper.

A plain cylindrical casting for use as a liner, in spite of its simple appearance, is difficult to make free from defect, especially if it has to withstand hydraulic or oil pressure. Usually these castings are machined over the entire surface and are required to exhibit no blemishes of any kind, and, moreover, to offer a high resistance to wear. Liners offer symmetry and evenness of section without intricate coring—conditions which make for uniform cooling and soundness. Nevertheless, the proportion of wasters made with these castings is probably as high as in any class.

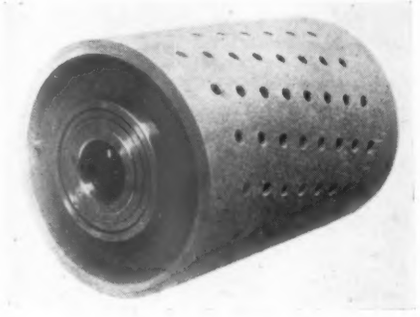

FIG. 3.—FINISHED REVOLVING LINER.

Adequate pressure heads of the self-feeding type are indispensable, together with top running. Fig. 1 illustrates three kinds of header for liner castings. That marked A is of the same section as the casting and cools at the same rate. Its extra metal is, therefore, not liquid long enough to give efficient feeding, and it is effective only as a sullage piece. Head B holds more metal and maintains it liquid after the thinner section below has set, so that it is available for counteracting liquid shrinkage taking place lower down. Theoretically head C gives the maximum self-feeding effect, because its centre-line coincides with that of the liner wall.

In practice type B has been found to give good results, in conjunction with equally-spaced top gates, giving an equal distribution of hot metal and ensuring that finally the hottest iron is in the feeding head, causing progressive solidification from the bottom upwards. Top pouring also keeps the surface of the rising metal in a state of agitation until the mould is full, thereby helping to prevent dirt or scum from remaining attached to mould or core walls and assisting its journey to the top. Deep liners have one bottom in-gate, which is opened a few seconds before the top gates, so that the latter deliver on to a cushion of metal. All the runners are fed from an ample horse-shoe-shaped runner basin of capacity about equal to the content of the liner head. The heads are about one-third the length of the liner and flared to give an average thickness of twice that of the wall. Whilst any casting section can be fed upwards from metal supplied beneath, it cannot be done with the same size of gates and gate pressure, nor to the same advantage as feeding from above, for in the latter case the force of gravity is acting with instead of against the operation.

Two small liners can be seen in the background of the group of miscellaneous castings shown in Fig. 2. The tapered head of the one on the left is just visible, at the bottom. Fig. 3 depicts a revolving liner in its finished state. It forms part of a rotary compressor and is free to revolve under the action of the blades expelled by centrifugal force from the slots in the rotor. Reference to Fig. 4 helps to make this clear. The holes form ports for the suction and delivery air. Due to the liner being free to revolve and carried round with the blades, much higher speeds of rotation are possible.

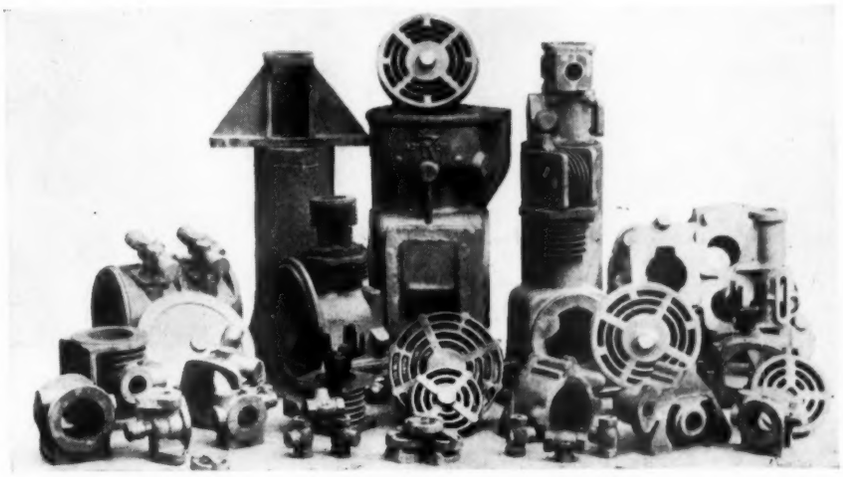

FIG 2.—GROUP OF SMALL MISCELLANEOUS CASTINGS.

Cast-iron Rotors

Fig. 5 illustrates diagrammatically the casting which forms a rotor for the type of compressor or exhauster just mentioned. From the viewpoint of moulding, it is a fairly simple, straightforward job. Ultimately, however, it forms part of a special machine (Fig. 4), which runs at 585 r.p.m., and must be a perfect casting in every respect. Machining is done over the whole of the outside surface, including both ends, the centre is bored out for the driving shaft and each of the six ribs is slotted to take a blade. Under running conditions the blades move in and out of the slots continuously at high speed. Thus, it is of the utmost importance that they work smoothly and uniformly in their housings. The jamming of a blade is capable of wrecking the machine.

Other vital considerations include accurate balancing of the rotor. To assist in this, the six segment cores need accurate making and positioning in the mould, where they are held by prints projecting through each end; the holes so formed are finally plugged, as shown in Fig. 4. Lubrication of the blades in their slots takes place by way of the driving shaft, so that no open-grained or porous metal can be tolerated in the bore or slots as oil, under pressure, would percolate into any of the various compartments formed by the ribs and throw the machine out of balance. No hard spots or non-uniformity of metal structure must exist, tending to deviate the milling cutter from its true path in cutting the long narrow slots, because it is essential for these to be dead true. The dimensions of the casting are given in Fig. 5, and it weighs 16½ cwts. Other similar rotors of smaller size are made, and the moulding and casting practice is the same. A hydraulic test is made on the bore and spaces between the ribs to ensure pressure-tightness.

With a casting of heavy section, such as this, liquid shrinkage has to be effectively counteracted, for in any place where a shrinkage defect might form, machining occurs to reveal it. In place of a sand core for the centre bore, a solid cast-iron stick 2⅛ in. dia. is used to ensure sound close-grained metal. This cannot be removed on fettling and is machined out. Fig. 6 shows five of the six segment cores in position round the centre densener; the pattern for making the latter is standing alongside the flat, circular core containing the top prints for the segment cores.

Nothing must prevent free expansion of the long densener, for extension from temperature rise when casting is considerable and if restrained bending occurs with disastrous effect

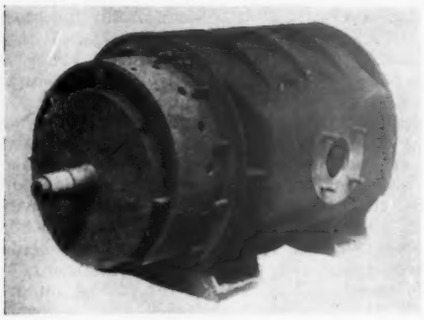

FIG. 4.—ASSEMBLY OF ROTOR.

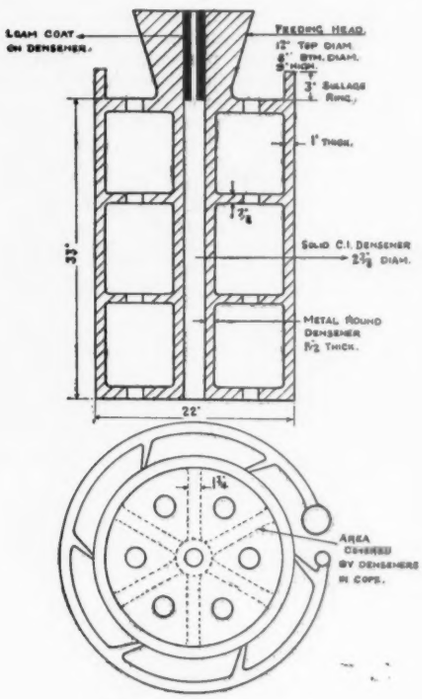

FIG. 5.—ROTOR CASTING.

FIG. 6.—FIVE OF THE SIX SEGMENT CORES IN POSITION.

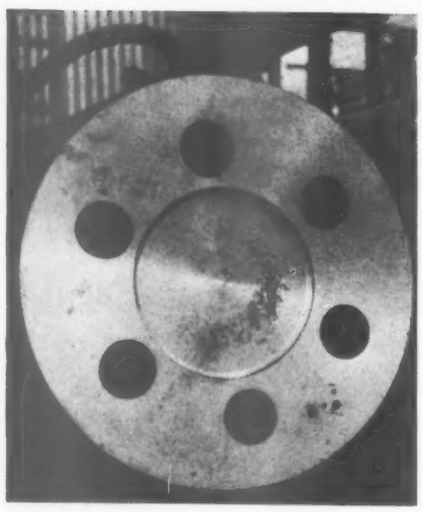

FIG. 7.—SHRINKAGE CAVITIES DUE TO FAULTY FEEDING.

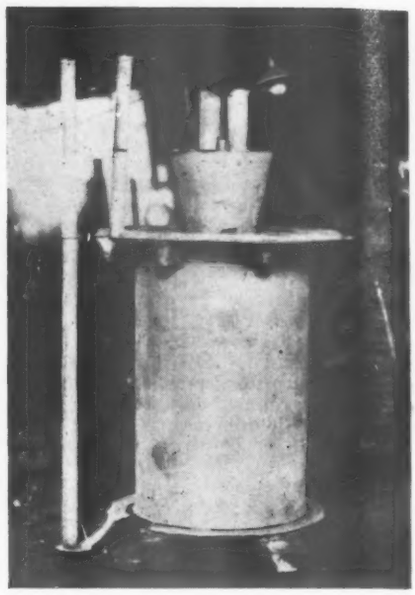

FIG. 8.—RUNNING AND FEEDING SYSTEM FOR CASTING SHOWN IN FIG. 5.

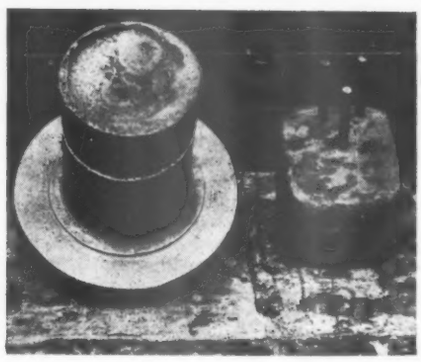

FIG. 9.—COUPLING CASTING AND PENCIL RUNNERS.

FIG. 10.—TYPICAL AIR CYLINDERS FOR COMPRESSORS.

FIG. 11.—JACKET AND VALVE CHAMBER.

on the bore. The densener does definitely give the desired result in that speed of cooling of the thick wall of the centre hole is so adjusted that it does not remain liquid long enough to allow of drawing away of metal by the radial and circular ribs which spring from it.

Solidification, however, causes a volume reduction which cannot be prevented, and is of considerable proportion for a casting such as this. Neglect to make provision for it is revealed by the appearance of shrinkage cavities on the top plate over the centre boss and radial webs (Fig. 7). To overcome this, the large feeding head, of dimensions shown in Fig. 5, is fitted. It is shown also in Fig. 8, together with the complete running and feeding system.

A limit to the dimensions of the feeding head is imposed from the fact that it may not interfere with the six vents from the segment cores, taken off from the top prints. Their relationship to it is seen from Fig. 6, which also shows the reduction in diameter of the densener over the portion which is contained in the head. The shouldered length is coated with loam to make it uniform in size; arrows chalked on it indicate the part referred to. If this precaution be not taken, the heavy densener will chill the head and seriously impair its value as a feeder.

Temperature and Speed of Pouring

Pouring temperature and speed are important factors in the making of castings of all kinds, although the permissible latitude varies greatly. A temperature of the metal higher than usual may help to eliminate shrinkage defects, although the amount of liquid shrinkage is greater. The hotter a cupola-melted iron is poured, the quicker and more uniformly it cools through the freezing range. Before solidification commences, the surrounding sand and cores become heated and tend to equalise the cooling speed throughout the casting. Actually, the mass of sand acts in the capacity of a heat accumulator, assisting natural feeding from the runners and risers and reducing casting strains.

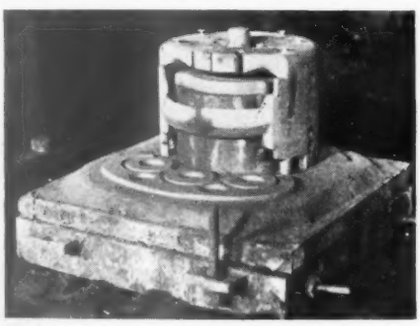

FIG. 12.—JACKET AND CENTRE CORES IN POSITION.

With the rotor casting, its symmetry of form is an asset in that it lends itself to uniform distribution of the metal by means of the two sets of six in-gates shown in Fig. 8. Two separate down-runners are used, one supplying the bottom gates and the other the top. Each of these down-runners is fitted with a plug and the bottom one is lifted first. After a fair amount of metal has entered, the other down-gate is opened and pouring finished by entry from the top gates. The method of running illustrated not only gives equal flow to all parts of the mould, but it helps to ensure progressive solidification upwards from the bottom with the hottest metal in the feeding head, a principle to be observed for all castings and previously stressed.

Respecting speed of pouring, experience is essential in gauging this satisfactorily. H. W. Dietert[5] has carried out much experimental work and made many calculations along these lines. A study of this aspect of casting production is worth while, because when pouring speeds are correctly adjusted, maximum self-feeding tendencies are encouraged.

A. McRae Smith[6] has said: "Good, hot, clean metal of the correct composition poured into moulds at the correct predetermined rate, with correct distribution in the mould, will always give perfect castings." Ronceray, too, has made investigations on this subject. While the pencil type of runner that he developed is applicable mainly to lumpy castings of simple design, it aims at supplying metal to the mould at such a rate that much of the liquid shrinkage has taken place by the time pouring is finished. Very hot metal is indispensable when pencil runners are employed. Heavy coupling castings are poured through pencil gates with great success. Before this principle was applied a solid densener was used to get the bore sound. Now the boss is extended, pencil gates equally spaced are cut on top, no centre core is used, and couplings poured with hot metal in this way turn out perfectly sound. The amount of liquid shrinkage which takes place can be seen from the sunken condition of the extended solid boss. Fig. 9 illustrates one such coupling and the details described.

Reverting to the rotor casting, the best results are obtained when the size of the gates and the metal temperature are adjusted to give a pouring time of 65 secs. When in-gates are too small, the time of pouring becomes lengthened, with the danger that the castings may not run, or part of the mould may drop due to prolonged exposure to the rising metal. In any case, it is likely that the movement of the metal is so sluggish that dirt and scum will be left attached to mould and cores and be trapped in corners. Too fast pouring, on the other hand, is inclined to produce dirty castings by reason of mould and core erosion and from difficulty in keeping the runners choked. Turbulence is set up and air and gases sucked into the mould.

Compressor Cylinders

Figs. 10 and 11 show typical air cylinders for a vertical, double-acting, two-stage compressor. The larger (Fig. 10) is the low-pressure and the other the high-pressure cylinder. They weigh 10 and 6 cwts. respectively, but larger ones are made. An idea of the bore, jacket and valve chamber is obtained from Fig. 11. Both cylinders are cast in the position shown in Fig. 10, although the high-pressure one is moulded in halves, on the flat, and turned up for casting.

Considering the low-pressure cylinder, the mould is made up of a bottom, three middles and a top part. It has two down-sticks—run simultaneously—terminating in a spray of four in-gates to each. One set enters the bottom flange and the other is cut in the joint which shows in Fig. 10. Risers are taken off from the top of the valve chamber and from the top flange; the latter is rod fed. A general idea of the jacket and centre cores in position is given from the view in Fig. 12.

FIG. 13.—GROUP OF CASTINGS INCLUDING COVERS AND PISTONS.

One single down-runner, with gates cut in the top and bottom flanges and at the shoulder, is used for the high-pressure cylinder. The top flange also takes the riser, which in this case is not fed. These cylinders are hydraulically tested in jackets and bores; also all the internal stud bosses must be sound.

Cylinder Covers

Two kinds of cover are shown with a group of other castings in Fig. 13. Attention is drawn to the number of stud bosses passing through the air and water spaces, which have to be free from porosity. The valve pockets, too, must machine cleanly and without blemish. Many other shapes and sizes of cover are made, but they nearly all possess similar features.

The large cover of Fig. 13 is moulded with the face showing in the drag. Runners and a riser are cut on the joint, and the riser is not fed. All the stud bosses are cast solid and pass right through water and air spaces, the walls of which are only $\frac{1}{16}$ in. thick.

(To be continued.)

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[5] H. W. Dietert, "The Foundry," March, 1930, p. 129.

[6] A. E. McRae Smith, "Foundry Trade Journal," Dec. 13, 1928, p. 429.

Some Cupola Troubles, Their Causes and Remedies*

By G. O. STANLEY

One of the most frequent troubles experienced in the blowing of cupolas is scaffolding, particularly in cupolas of small diameter. Scaffolding is caused through the charges of iron and coke becoming wedged in the cupola shaft. If blowing is continued for any length of time after a scaffold has occurred, the bed coke is partially burned away and results in irregular working of the cupola until the defect has been remedied. A scaffold or "hang up" may be caused by one or more of the following:—

(1) Irregular-shaped or oversize pieces of pig or scrap.
(2) Uneven distribution of the coke or metal charges.
(3) Uneven lining.
(4) Weak friable coke, which breaks down to small size under the burden, and is subsequently blown out of the cupola by the blast.
(5) A highly viscous slag caused by a deficiency of limestone in the charge. A pasty or "lazy" slag quickly solidifies on coming into contact with the chilling action of the blast, causing the slag to "build up" just above the tuyeres.
(6) Bed coke which is too low in the furnace results in there being insufficient fuel to melt the metal charge. This yields a pasty or semi-melted metal "bridging" the cupola at tuyere level.

If the scaffold is just above the tuyeres it may be removed by poking at the offending material through the poke holes. Should the scaffold be in the region of the melting zone it may be removed by filling the tuyeres with coal before restarting the blast. This causes intense local heat in the melting zone usually sufficient to melt the obstruction. If this is not successful, repeating the operation and allowing the cupola to soak for a while after a short blow should be tried.

If the "hang up" is in the cupola shaft and near the charging door it may be dislodged by a long bar, and if the scaffold is above the melting zone but not accessible through the charging door, filling the tuyeres with coal and blowing intermittently usually removes the obstruction.

The remedies for a scaffold due to causes (1), (2) and (3) are obvious. A close control of the physical properties of the coke will usually alleviate trouble due to weak, friable coke. A good cupola coke should have a shatter index of 85 to 90 (minimum). If the scaffold has been caused by a "pasty" slag or loss of bed coke, as much as possible of the obstruction should be removed through the tuyeres, and the tuyeres then be filled with coal. The charging of extra coke and limestone together with a few charges of suitable light scrap is beneficial in helping to melt the obstruction.

Obtaining a Fluid Slag

After scaffolding has been experienced, it is good practice to charge extra coke and limestone, and the tuyeres should be watched carefully in order that coke may be raked over any tuyere showing signs of being short of fuel. Difficulty is sometimes experienced in getting slag to run well. This may be caused by insufficient limestone being charged, or through using scrap containing a larger quantity of dirt than usual. Extra limestone should always be added when charging very dirty or rusty scrap. If high-temperature metal be required, it may be necessary to charge a little extra coke to fuse the added limestone.

The correctness of the practice may be judged by the colour of the slag. It should be fluid, green or brown in colour, and vitreous. Black dead-looking slags contain a high iron content, indicating insufficient limestone. If the analysis shows the slag to be of a suitable composition, examination should be made for any crevice in the lining through which blast may penetrate and chill the slag.

A slag hole too near a tuyere will also have this effect, and preferably it should be at least 6 in. below the tuyere level and never immediately underneath one.

Fluorspar is a very active fluxing agent for cupola slags; as little as 5 per cent. of the weight of the limestone is sufficient to increase the fluidity of the slag. Under favourable conditions soda ash also is useful for increasing the fluidity and dissolving action of the slag. As a rule, 25 per cent. of the weight of coke consumed in melting is a satisfactory proportion for the limestone addition.

Metal Control

Another source of trouble is metal composition. Consistent results depend upon the efficient mixing of the constituents. Where chemical analysis is the basis of calculating for a suitable mixture, the analysis of all the materials must be known. Extremes in the analysis of the constituents should be avoided. For instance, if a medium phosphorus content be desired and high-phosphorus scrap or pig is used in conjunction with hematite iron or steel scrap, a wide variation exists and special care is needed in charging if a homogeneous metal is to be obtained. A receiver working in conjunction with a cupola is desirable in procuring a metal of uniform composition.

The method of charging also has an effect upon the final composition of the metal. The usual method of charging is to place the steel scrap immediately on top of the coke charge, then the pig-iron and heavy scrap, and finally the light scrap. This method ensures the steel being melted first, thus enabling it to pick up sufficient carbon to establish equilibrium. When melting charges of this nature in a cupolette and the metal is required hot and fluid for small light castings, a homogeneous metal may be obtained by thoroughly mixing up the materials before charging.

The use of a large proportion of scrap, particularly bought scrap, generally causes an increased sulphur content which may result in hard spots or shrinkage trouble in the casting. For high-class work 50 per cent. of selected scrap is a safe limit. For rougher work up to 80 per cent. of scrap may be used with 20 per cent. of high-manganese pig.

The total carbon is affected by the volume and pressure of the blast. It is usually found that large volumes and low pressure give the best results. When a cupola is being blown down, the volume of blast should be kept constant in order to avoid scouring of the lining. It is usually found that a cupola running under standard conditions will produce an iron with a definite total carbon content.

A difficulty in small jobbing foundries is the

(*Continued at foot of third column.*)

* Entry in a Short Paper Competition organised by the Middlesbrough Branch of the Institute of British Foundrymen.

Life Insurance Premiums

PROTECTION AGAINST POLICY FORFEITURE

The payment of insurance premiums at the present time may cause conjecture by many persons hit by the war, and the following notes concerning an arrangement between the Board of Trade and the insurance companies and a new Act which give protection against forfeiture of policies may be useful.

The arrangement applies to ordinary policies (both whole life and endowment policies), and by this policies will be kept alive so long as there is sufficient surrender value (payment of two years' premiums will be considered as having acquired a surrender value) to meet the amount required for premium payments. Where there is insufficient (or no) surrender value to apply, the companies have promised to treat each case as generously as possible. If, notwithstanding the protection afforded, there are cases where the policy lapses, consideration will be given to a favourable revival of the policy, after the end of the war. If a claim arises while the protection lasts, the full sum assured will be paid, less the amount of unpaid premiums and interest thereon.

Period of Grace

The Act (styled the Industrial, etc., Assurance Act, 1940) applies to policies up to £50 (any bonus ignored) which were in force before September 1, 1939, and upon which two years' premiums have been paid (paid before March 14, 1940). In brief, it gives power to companies to give protection against forfeiture, if satisfied that the reason for non-payment of premiums is due to the war, that is the payment of premiums may be suspended until after the war. Then, if within a period of three months from the date laid down as constituting the end of the war, called "the period of grace," the arrears are liquidated, the policy holder will be in the same position as if there had been no arrears contracted. If the arrears are not then paid (or only partly so) the sum assured will be reduced by an amount arrived at under a formula in the Act (based on age groups). Where the policy is an endowment policy, payment of the arrears will restore the policy as before; if arrears are not paid, the date of maturity will be extended by the period during which premiums are not paid. As an example, suppose the policy is one to mature at the age of 60, and no premiums were paid for two years, the age of 62 would be substituted for the age of 60 as the date of maturity.

If a claim arises before the end of the period of grace, and arrears have not been paid, the amount payable will be reduced by the amount of the premium arrears with interest.

(*Continued from previous column.*)

separation of different types of mixtures. This may be effected by placing an extra charge of coke between the mixtures. This extra coke temporarily holds up melting by being burned itself and thus allows the preceding mixture to be drained off before the second mixture is fluid. This does not solve the problem completely, and it is policy to use the intermediate metal for castings not made to any specific analysis. A more satisfactory method, if conditions permit, is to blow the cupola down, drain the well, make the coke bed up to correct height and charge up again. The first iron melted should be used for castings that do not call for definite analysis, or should be "pigged." The quantity of metal needed to be used in this way will not be so great as by the previous method.

Gravity and Pressure Die-Casting*

By ARTHUR STREET, B.Sc., Ph.D.

In peacetime, the die-casting industry was rapidly attaining recognition by many manufacturing concerns that used bulk quantities of metal fittings. Since the outbreak of war, the process has stepped to a position of first-rate importance. There are several firms which as a result of the war, have been called on to use die-castings and it was thought that a few notes dealing with the application of die-castings might be helpful, particularly to those who up to the present have not had much to do with the products of the process.

It is well known that there are two forms of die-casting, gravity and pressure die-casting. The former process is a manually operated method of production which only differs from sand casting in that the mould is permanent, usually of special cast iron, and the cores are generally of alloy steel.

In pressure die-casting the various operations are made as nearly automatic as possible. The die is opened and closed mechanically, the cores are inserted, extracted and held in position by similar means and the finished casting is ejected from the die face by a series of ejector pins. The main distinguishing feature of pressure die-casting is that the alloy is "squirted" into the mould under high pressure.

The "Polak" hydraulic die-casting machine represents the "cold chamber" type of machine—the metal is melted separately and is ladled into the injection chamber before each shot. The "Kippcaster" represents the "hot chamber" type, where the molten metal is held in a crucible which is part of the machine and the injection mechanism is permanently in contact with the molten alloy. Owing to the injection of the metal under pressure and to the minimisation of the human element, the surface appearance and accuracy of a pressure die-casting are superior to those of a gravity casting.

Table I attempts to summarise some useful information about pressure and gravity die-castings. For instance, it shows that a part which contains a number of small holes and a cast thread should not be die-cast in a high melting-point alloy like aluminium bronze, if it is desired to eliminate machining operations. Perhaps the table will also stress that pressure die-casting is not a suitable method of production if only a few hundred parts are required, whereas gravity die-casting does lend itself to the making of small quantities.

Since the war began, two features of die-casting, which were previously of only secondary importance, have assumed major importance.

(1) The pressure die-casting process in particular can undertake the production of immense quantities of metal parts. Table I indicates something of the rate of output which can be obtained. Certain designs which are required in large quantities lend themselves to production from a multiple impression die; this is particularly the case when the items are small and have cored holes in one direction only; sometimes, a dozen or more die-castings are produced at each shot. For certain important jobs the die-caster may have six or more dies all working at the same time.

(2) The time has passed when all components must be machined out of the solid just because they were intended for the use of the Services. Instead, modern methods of fabrication are being used to the fullest extent so as to avoid unnecessary machining.

Pressure die-casting allows the manufacturer to economise in machine-shop labour. Limits of the order of plus or minus 0.0015 in. per in. can be maintained (particularly in the zinc-base alloys). Many holes can be cast to such close limits that machining becomes unnecessary, and if a hole has to be specially accurate and free from taper, it can be cored in the die-casting with a small machining allowance so that a single operation finishes the good work. More especially in the zinc-base alloys, external and internal threads can be cast, usually without a joint line and accurate enough to make machining unnecessary.

Alloys for Die-Casting

Using the die steels which are available at present, die-casting can only be economically applied to the fabrication of certain alloys, chiefly of low and medium melting point; for instance, steel or Monel metal cannot be die-cast, whereas aluminium alloys, 60/40 brass and zinc-base alloys are very suitable for die-casting. Before an alloy can be die-cast it must possess the following qualifications:—

(1) Its melting point should not exceed 1,000 deg. C. The casting temperature of the alloy is reflected to a magnified extent on the wear which the tool suffers. Thus, for zinc-base alloys (melting point 400 deg. C.) the die life is of the order of hundreds of thousands, and sometimes millions of shots. For aluminium alloys (melting point 550 deg. C.) die lives of about 50,000 are expected, while for copper-base alloys (melting points 900 to 1,000 deg. C.) a die life of 10,000 to 15,000 is usual.

(2) The alloy must not be hot-short or it will crack on account of being rapidly chilled against the constraint of the steel mould. In this respect the pressure process is particularly searching. Thus the aluminium-zinc-copper alloy, L.5, which can be sand cast, is difficult to gravity die-cast, and almost impossible to pressure die-cast.

(3) The alloy must not attack the mould material; for example, pure zinc would galvanise the die, but if the metal is alloyed with about 4 per cent. of aluminium, the solution action is prevented.

Several non-ferrous alloys possessing the qualities which make them "die-castable" have been adopted by the industry as being specially suitable. Among this range of alloys will be

TABLE I.—*Data on Gravity and Pressure Die-Casting Methods.*

	Gravity die-casting.	Pressure die-casting.
Operation ..	Permanent metal mould operated manually. Alloy poured from ladle.	Mechanically operated as regards opening and closing of die, movement of cores and ejection of finished casting. Metal injected into die at high pressure.
Die material ..	Cast iron: Alloy cast iron, etc. Cores and certain important parts of die often in alloy steel.	Usually heat-treated alloy steel.
Suitable quantities.	May be used for any quantity from 500 upwards.	Job for job a pressure die will be two or three times as expensive as a gravity one. On account of high cost of tooling and setting-up, this process mainly becomes competitive when quantities greater than 5,000 are involved. For very large numbers, process usually becomes preferable to gravity die-casting.
Life of die ..	Average figure is 10,000 shots ..	Depends on melting point of alloy, condition of heat-treated steel die and complexity and weight of casting. Average figures are:— Zinc alloy .. .. .. 200,000 or more. Aluminium alloy .. .. 20,000 to 80,000. Copper alloy .. .. 5,000 to 20,000.
Rate of output (depends on design of part)	Average 250 shots per shift .. For large quantities it pays to have duplicate sets of tools.	Fully automatic machine die-casting *small* parts of simple design can produce as many as 10,000 shots per shift. For parts of normal size, usual type of machine is used and production is about 1,000 to 1,500 shots per shift. N.B.—Multiple impression tools are often used to produce several castings per shot, so that frequently a normal type of machine, using a multiple impression mould, can produce as many die-castings as a fully automatic one.
Alloys available	Practically any alloy that can be foundry cast and is not hot-short can also be gravity cast. Process suitable for alloys to be heat-treated. Aero work in particular.	More limited than gravity process. Usual alloys which are widely pressure-cast are zinc alloys (Mazak type), aluminium-silicon, aluminium-copper-silicon, and sometimes aluminium-copper alloys.
Accuracy ..	Average plus or minus 0.005 in. per in.	Zinc alloy .. Plus or minus 0.0015 in. per in. Aluminium alloy Plus or minus 0.00 25 in. per in. Copper alloy .. Plus or minus 0.003 in. per in.
Minimum size of holes which can be cored. (Depends on conditions.)	Zinc alloy .. .. $\frac{1}{4}$ in. Aluminium alloy .. $\frac{3}{16}$ in. Copper alloy .. .. $\frac{1}{4}$ in.	Zinc alloy .. .. .. $\frac{3}{64}$ in. Aluminium alloy .. .. $\frac{1}{2}$ to $\frac{3}{16}$ in. Copper alloy .. .. .. $\frac{3}{16}$ in.
Taper required on holes, etc.	About 0.025 in. per in. of length ..	Depends on alloy and on design of job. Zinc .. .. 0.003 in. per in. of length. Aluminium .. 0.02 in. per in. of length. Copper .. .. 0.02 in. per in. of length.
Undercuts ..	Heavily undercut designs can be executed. Sand cores can be used. Process not so flexible as sand-casting with regard to undercuts, but more so than pressure die-casting.	Certain undercuts involving rotating or knock-out cores can be used, but process not so suitable for heavily undercut portions. Sand cores should not be used.
Surface appearance.	Better than sand-casting, but marks usually remain at position of runner, riser and die-parting.	Of very high order—runner position practically undetectable, but faint evidence left of ejector pins and die parting.
Threads	Coarse external threads can be produced in aluminium and zinc alloys.	Depends on alloy. Zinc alloy—external 24 to the inch. —internal 12 to the inch. Aluminium alloy—external 12 to the inch. —internal—inadvisable to cast. Copper-base alloy—inadvisable to cast threads.

* Extracted from a Paper issued by the Manchester Association of Engineers.

found most of the physical properties which may be desired. The die-casting alloys may be divided into four groups, depending on their melting point:—(1) Tin and lead base alloys; (2) zinc-base alloys; (3) aluminium and magnesium alloys; and (4) copper-base alloys.

Aluminium Content of Die-Castings

Most of the widely-used die-casting alloys contain aluminium. For instance, the zinc-base alloys have 4 per cent., aluminium bronze has about 10 per cent., and the light alloys contain anything up to 95 per cent. of aluminium. The presence of aluminium means that soldering becomes difficult or even impossible. There are several "dodges" which can be used if one really must solder a die-casting; for instance, aluminium solder can be used. It is possible to nickel-plate the die-casting and solder on top of the nickel, or one can "cast-in" a brass insert and solder on to the brass. Nevertheless, the fact remains that the soldering of die-castings has always been troublesome.

The limitation, however, proved to be a boon to all concerned, because when a would-be die-casting user was told that he could not solder the die-casting he usually made some alteration in design so that the soldering could be eliminated. One customary thing was to re-design the part so that the two or more components, which were previously soldered together, were now made as a one-piece die-casting.

Zinc-Base Alloys

Die-casting manufacturers and users owe much to the New Jersey Zinc Corporation of America, who are largely responsible for developing these essentially die-casting alloys and for bringing them to a state where they could be used with confidence by engineers. It may be remembered that at the time of the last war, zinc-base alloys were used, but they were certainly not of the same composition or properties as they are to-day. The old alloys were weak and brittle and, what was worse, they deteriorated in use. Cases were known 25 years ago where zinc-base die-castings completely disintegrated after a few months' service! After many years of prejudice, due to memories of the history of the early alloys, the modern improved zinc-base alloys became deservedly popular.

These alloys are based on the composition aluminium 4.1 per cent., balance zinc. The purity of the base metal is the key to the reliability of the alloys, for they are amazingly susceptible to the influence of certain impurities. As little as 0.002 per cent. tin or lead will make the alloy susceptible to intercrystalline corrosion. The zinc which is used in these die-castings is always specified as being of "99.99 plus" per cent. or "four nines" quality.

The straight zinc-base aluminium alloy referred to above, usually known as the No. 3 alloy, seems to be preferred by some important users. It should be mentioned, however, that there are two other alloys in wide use, both containing 4.1 per cent. aluminium, but with additions of copper which bring about an improvement in tensile strength. One alloy (best known by the trade name of Mazak No. 5) contains 1 per cent. copper and the other (known as Mazak No. 2) contains 2.7 per cent. copper. The copper-free No. 3 alloy has the advantage that it maintains its impact strength both at slightly elevated temperatures and under corrosive conditions, while the two copper-containing alloys, particularly that with the 2.7 per cent. copper, do suffer some loss of impact strength (see Table II). A few years ago the harder and stronger No. 2 alloy was the most widely used, but now manufacturers are preferring the No. 3 and No. 5 alloys. Mainly as a stabiliser, a small percentage of magnesium (less than 0.1 per cent.) is included in all the compositions.

TABLE II.—*Physical Properties of Three Zinc-Base Alloys.*

	Mazak No. 2.	Mazak No. 3.	Mazak No. 5.
Composition:			
Al	4.1	4.1	4.1
Cu	2.7	—	1.0
Zn of 99.99 per cent. purity and about 0.03 per cent. Mg	Balance	Balance	Balance
Tensile strength. Tons per sq. in.	19—21	15—17	18—19
Elongation, per cent. on 2 in.	3—8	2—5	3—6
Brinell hardness	83	62	73
Impact strength (as cast), ft.-lbs.	19	20	17
Impact strength (after 10 days in steam), ft.-lbs.	1	20	11
Electrical conductivity, per cent. (copper 100 per cent.)	26	27.5	27
Weight per cub. inch	0.25 lb.	0.24 lb.	0.25 lb.
Melting point, deg. C.	379.3	380.9	380.0

TABLE III.—*Composition and Properties of Some Light Alloys Used in Die-Casting.*

	Major constituents.						Tensile strength. Tons per sq. in.	Elongation on 2 in.	Brinell hardness.	Notes.
	Al.	Mg.	Si.	Cu.	Ni.	Zn.				
Aluminium alloys:										
L.33	Bal.	—	11—13	—	—	—	11—13	3—6	55—65	Suitable for either process, but especially for pressure die-casting.
L.8	Bal.	—	—	12	—	—	9	1.2	75—80	Preferably gravity die-cast.
L.5	Bal.	—	—	3	—	11—13	11	3	60—70	Hot-short—therefore only suitable for simple shapes in gravity die-casting. Unsuitable for pressure die-casting.
L.24 (Y. alloy)	Bal.	1.5	—	4	½	—	18—20	2	95—100	Usually heat-treated before use. High-duty alloy especially used in gravity die-casting.
Al-Cu-Si alloys	Bal.	—	3	2	—	—	10—12	3.5	55—65	Suitable for pressure die-casting and machines rather better than straight Al-Si alloy

Zinc-Base Alloys as Substitutes for Aluminium Alloys

A user of aluminium alloy die-castings who may desire to change to the use of zinc alloy will in many cases find that the same tool can be used. The contractions of the zinc alloy and aluminium are so similar that there is no need to worry about the variation in dimensions through using the alternative material. Being a stronger material, the zinc alloy may turn out to do the job better than the aluminium alloy which it replaces. The weight of the zinc alloy is about 2½ times greater than that of aluminium. The cost per pound will work out at about a third, so that the price of the zinc-base die-casting will not be much different from that of the same part in aluminium—if anything, it might be a little cheaper.

The question of increased weight should be borne in mind. There are several manufacturers of domestic appliances who are now using zinc alloys in place of aluminium and by so doing they have added appreciably to the weight of their appliances. Sometimes the problem involves more than a mere addition to the weight. For instance, there is one case about which the author has still not made up his mind. A pair of aluminium alloy die-castings go to make a coupling which has to revolve at high speed. If the material is changed to zinc alloy the strength will be nearly doubled, but on account of the increased weight the centrifugal force will be multiplied by 2½. Consequently, the tendency to breaking will be somewhat increased. This is an exceptional case, but even here a change of alloy will probably be worth trying.

In some cases where a change-over from aluminium to zinc is made, it is worth while to have a completely new tool. The reason for this is that much more detail can be cast in a zinc alloy die-casting than in aluminium, because of the lower melting point. Further, as will have been noticed from Table I, the taper which is required for cored holes, etc., is considerably less in zinc than in aluminium.

Die-Castings in the Light Alloys

The alloys of aluminium and magnesium are fabricated by both gravity and pressure die-casting, with emphasis on the former process. There are many reasons why a greater tonnage of gravity die-castings is being produced in the light alloys. They are used for very many important jobs each of which is required in medium quantities only, where gravity die-casting works out cheaper. Then many such parts are required to be heat-treated and the gravity process lends itself better to the die-casting of the heat-treated alloys. There is another important point; components like automobile pistons and a number of aircraft parts are so much "undercut" that gravity die-casting (which involves hand manipulation of cores) is a more suitable method of dealing with this particular type of complexity.

The most suitable weight for pressure die-casting in aluminium alloy at the present time lies between 1 oz. and 4 lbs. The quantities involved are usually greater than 5,000. The section of a pressure die-casting should be uniform and should lie somewhere between $\frac{1}{16}$ in. and $\frac{1}{4}$ in. Although certain types of undercuts are possible, the pressure process is more limited than gravity die-casting in that respect.

The pressure die-casting industry has concentrated on a few aluminium alloys which have lent themselves particularly well to the process. Table III shows the compositions and properties of some of them.

Chromium Heat-Resisting Cast Irons

By R. C. TUCKER, M.A.

(*Continued from page* 471.)

Testing for Elevated Temperature Use

A few words about the testing procedure for scaling, growth and strength at high temperatures are necessary in order to show why some of the author's results are not in accord with earlier work.

Growth Tests.—Outibridge carried out tests on test-bars held in cast-iron pipes plugged with clay. Carpenter and Rugan heated their bars to 900 deg. C. in a cast-iron muffle, enclosed in a brick muffle to avoid direct flame. Donaldson heated his bars to 800 deg. C. for 8-hour periods, and all these experimenters had trouble with scale and in fact measured growth plus scale.

Fortunately, most of their irons grew so much at these temperatures that the results were not greatly affected and their results are mostly correct. When, however, as in Donaldson's early work,[1] a test-bar containing chromium was tested, 0.28 per cent. *shrinkage* was noted. The author's earlier tests also used machined bars and included the scale, but above 650 deg. C. the results were very erratic and at 750 deg. C. the scale often flaked off during a series of heating cycles and gave a negative growth.

In 1938 Benson and Allison presented a Paper to the Bradford Conference of the Institute, in which they described a growth test-piece consisting of a bar machined to ¼ in. carrying measuring pips at each end, and protecting these pips by pressed-on mild-steel caps. For short tests and fairly low temperatures (650 deg. C.) this worked well in the author's hands, but for the now imperative long-time tests and for higher temperatures, the caps stick and leak; moreover, phosphoric irons, which become embrittled, often break before the caps are removed.

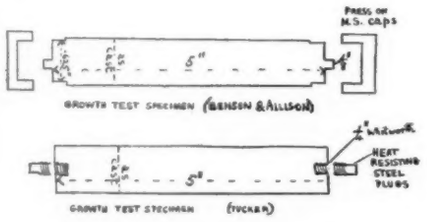


FIG. 6.—GROWTH TEST-PIECES.

The author has therefore adopted the test-piece shown in Fig. 6. The studs at each end are of heat-resisting steel and are machined to ¼ in. Whitworth and screwed into the tapped holes in the ends of the 5-in. test-piece. The assembly is then ground parallel and measured. The greater thermal expansion of the steel holds the stud firmly in position. These studs are satisfactory up to at least 1,100 deg. C. With these pieces growth tests of great accuracy can be carried out up to 900 deg. C. for long periods.

The author uses an ordinary Vernier caliper reading to 0.001 in., which has proved quite satisfactory for works purposes. It corresponds to 0.02 per cent. on 5 in.

It is found that, for heat-resisting cast iron, tests of 250 hours' duration at 5-hr. cycles are the shortest tests which give uniform growth at 650 deg. C., and at 750 deg. C. the test should not be much shorter. These carbide-network irons change their structure only slowly on heating and finally reach a state where the excess carbide decomposes and spheroidises in a ground-mass of ferrite.

It is interesting to note here also that in the cantilever test the rate of deflection is high at first and decreases to a small rate after 50 to 100 hours. The growth rate at 650 deg. C. is also large for the first 100 hours, and then gradually becomes very small. These points are brought out by the typical curves shown in Fig. 7. Here the rapid growth of the carbide network (Fig. 3) is followed by a marked falling-off, while the unalloyed cylinder grey iron grows normally.

Fig. 8 shows growth tests at 750 deg. C. and here the cylinder iron has a high rate of growth, slightly exceeded by the iron V4, which is the same iron containing 0.3 per cent. chromium, and which is still grey (combined carbon 0.75 per cent.). The higher alloyed irons of slightly differing compositions chosen for their range from hard to soft fracture all fall into a group which have much flatter curves, but different rates during the first 50 hours. At this temperature it seems that it is wisest to err on the side of softness in these irons (obtained by higher silicon, not by lower chromium), and, as this gives better founding and machining properties, this is sought in practice.

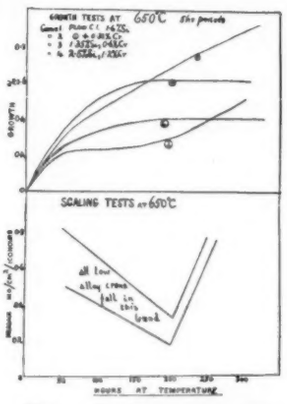


FIG. 7.—GROWTH AND SCALING TESTS AT 650 DEG. C.

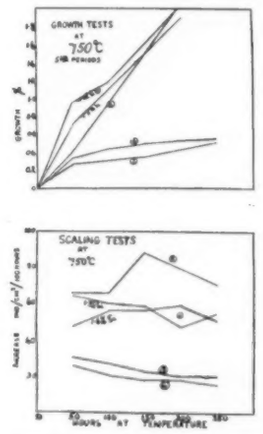


FIG. 8.—GROWTH AND SCALING TESTS AT 750 DEG. C.

Scaling Tests

The scaling of these irons is examined by introducing into the same muffle as the six growth bars, six 1-in. lengths of the same test-bars, previously weighed; these are re-weighed when the bars are measured, *i.e.*, after every 50 hours at temperature. The bars are 0.875 in. in diameter and the gains in weight increase greatly between 650 and 670 deg. C. This is shown in Figs. 7 and 8.

Strength Tests

The strength of these irons at high temperature is difficult to measure. Practically the only work published on the creep of cast irons is in a Paper[2] by Tapsell, Becker and Conway. The irons and temperatures chosen were unfortunately incompatible, as the austenitic Nicrosilal proved unstable and became martensitic. The use of higher nickel renders these irons more stable, and it is understood that better results were obtained later. Short-time tensile tests are worthless except as a first attempt. Prolonged tensile creep tests are complicated by the growth occurring at the same time. As even creep-test data on steels must be correlated with previous engineering experience before they can be used and then an arbitrary figure chosen as a standard for comparing different steels, there seemed to the author no fundamental reason why an empirical test should not be applied to cast iron and the behaviour of known irons in the test and in service correlated.

Some years ago the B.C.I.R.A. installed a cantilever test, and did some interesting tests on it. The author, attracted by the idea, made inquiries and found some of the conditions under which these tests were carried out. The fact that the plastic bending of a bar cannot be calculated to fibre stresses, prevents this test from becoming a direct measure of strength at high temperatures, but, as an empirical way of studying the rigidity of cast irons at various temperatures, it offers the advantage of simplicity and the elimination of growth interference.

Fig. 9 is a diagram of the apparatus set up by the author to study this question. In a small and crowded works laboratory it was necessary to make the apparatus compact. A massive frame of welded mild steel carries the 0.875 in. dia. "as-cast" bar and a Nichrome-wire-wound furnace fits over the bar and just allows the insertion of a platinum—platinum-rhodium thermocouple (without sheath) and also allows some bending of the bar. The load must be chosen so that the rate of deflection is very small in order that long-time tests will not cause the bar to bend far enough to foul the furnace tube. This construction was in the nature of a first attempt, and in the present reconstruction of the furnace a split tube internally wound with a Nichrome spiral is being installed. The deflection is measured by the tilting mirror which operates by a Meccano chain attached to the bar 10 in. from the centre of the furnace, and which is carried over a Meccano sprocket on the same rod as the mirror. The chain is held in slight tension by a lead weight hung at the end.

The load is applied by a dead weight hung at 10 in. from the centre of the furnace. In series with the Nichrome furnace (26 s.w.g.) is another furnace wound with thicker wire (20 s.w.g.). In this is a glass bulb operating a mercury make-and-break, which regulates the current and temperatures of both furnaces. The bulb attached to the other end of the U-tube is maintained in melting ice in a thermos flask. By means of this regulator the temperature of the small furnace round the bar could be controlled within 15 deg. C. for long periods.

The light from a galvanometer lamp was reflected from the tilting mirror on to a galvanometer scale, and it was found convenient to construct the apparatus so that 1 cm. deflection on the scale corresponded to 0.012 cm. deflec-

tion on the bar. This could easily be altered by varying the size of the sprocket wheel or the distance of the scale from the mirror.

It was found very early that cast irons do not have a constant rate of deflection and that at 650 deg. C. the rate falls off to a very small value. At 750 deg. C. the rate is, of course, greater, but falls off to a small constant value. It is only possible to quote a few isolated tests, because each test takes several weeks and the apparatus is not yet in its final form.

An engineering iron and a chromium-alloy heat-resisting iron containing more than 1 per cent. chromium have about the same rates of deflection at various stages and at 650 deg. C. The rates fall off rapidly in the first 20 hours, and after two weeks attain very small values. A long time has been spent in choosing suitable loads and temperatures for long-period tests (up to several months). It was proved that short-

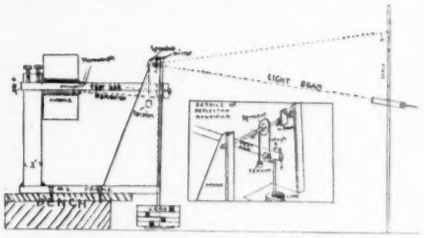
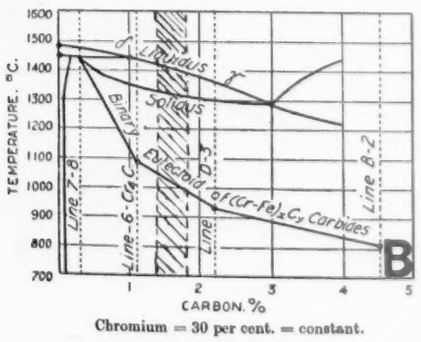


FIG. 9.—CANTILEVER TEST FOR STRENGTH AT ELEVATED TEMPERATURES.

time tests have little value, and it is disturbing to see the rates of deflection at 750 deg. C., even at loads as low as 10 lbs., in the first few days. The method shows great promise of sorting irons into a series, but up to the present the chromium addition cannot be said to have strengthened the iron at high temperatures to any great extent.

It is intended finally to determine the influence of phosphorus, nickel, molybdenum and tungsten on the "creep" of cast iron, but it will be a long time before the series is completed. The next material to be tried will be a mild-steel bar for comparison purposes.

The effect of temperature on strength is mentioned by Pfannenschmidt,[3] who measured the tensile strength at room temperature after several hours at different high temperatures. His low-silicon, low-chromium cast iron "Cr" actually increases in tensile strength even after



Chromium = 30 per cent. = constant.

FIG. 10.—SECTION THROUGH THE FE-CR-C SYSTEM (TEMPERATURE AND CONCENTRATION DATA ARE APPROXIMATE).

120 hours at 900 deg. C., whereas a nickel-chrome cast iron began to show permanent damage after 48 hours at 800 deg. C., and a cylinder iron at 600 deg. C.

At the same conference Morgan, of the B.C.I.R.A. refers to the cantilever test and states that even brittle irons bend readily at 850 deg. C., and that increases in silicon increase the stiffness, but the tests mentioned lasted only four days, which may be long enough at 850 deg. C., but is very much too short a time at 650 deg. or 750 deg. C.

The introduction of small percentages of chromium is shown to be under close control and to have beneficial effects on growth and scaling while machinability and toughness are unimpaired.

High-Alloy Cast Irons

The last section of this Paper deals with the high-alloy cast irons, which, because of their high cost, exceptional properties and special manufacturing methods, fall into a class by themselves. Smalley, in 1932, made the statement in discussing Morgan's Paper (*loc. cit.*) that 8 per cent. chromium electric-furnace steel was cheaper and better, but forgot that Morgan has specifically stated that austenitic cast irons were best used above 850 deg. C. because of the possible danger of the austenite becoming unstable. This is prevented by high nickel, but there is no published information showing whether the stabilisation is indeed 100 per cent. or merely improved. An 8 per cent. chromium steel is best used at temperatures about 650 to 700 deg. C., at which temperature the low-chromium cast irons could be a serious and cheaper competitor. The austenitic cast irons Nicrosilal and Ni-Resist are well-known and excellent materials to use in situations where replacement means the interruption of production and entails high labour costs.

They are scale resistant up to 1,000 deg. C., do not grow appreciably, and have appreciable strength in bending at 850 deg. C. (Morgan. *loc. cit.*). P. A. Russell and others have delivered Papers to this Institute showing that, although cupola melting is possible, it is too erratic, and oil-fired or electric furnaces are much superior.

Many investigators have reported the excellent effect of aluminium in moderate quantities in promoting the scale resistance of cast irons. The difficulty of alloying aluminium with regularity and without the formation of oxide was almost insuperable for practical development until the introduction of a special technique[4] patented by the B.C.I.R.A. and the Dominion Ferro Alloy Corporation.

The resulting iron is known as Cralfer, and contains 7½ per cent. aluminium and some chromium. The resistance to growth at 950 deg. C. is given in the literature, as follows:—

Grey iron	24.0% by volume	After 6 × 3 hours + 1 × 20 hours at 950 deg. C.
Silal	1.5% „ „	
Cralfer	1.3% „ „	

There is no published information about strength at high temperatures or long-time growth tests, and it is to be expected that this material is a growth- and scale-resistant alloy only.

The 30 to 35 per cent. chromium cast irons have been known for many years and used for scale resistance and resistance to sulphur-containing flue-gases below the dewpoint. There must be a relation between the chromium content and the carbon content because the carbon forms chromium carbides first and then the excess chromium is dissolved in the ferrite. This chrome-ferrite must have sufficient chromium to be scale-resistant. In the author's foundry the material is crucible melted. Valenta[5] gives an excellent account of these alloys from the metallurgical standpoint.

Fig. 10 shows a cross-section of the ternary iron-carbon-chromium diagram at 30 per cent. chromium, which shows that this material melts at 1,400 deg. C. and no phase change occurs below 1,000 deg. C. (carbon 1 to 2 per cent.). It is found from experience that at this chromium figure (and up to 35 per cent. Cr) and below 1.5 per cent. carbon the "life" of the alloy is impaired greatly.

There are no crucibles of 400 lbs. capacity commercially available in this country except graphite, and carbon pick-up in these is excessive with low-carbon alloys. Above 2.2 per cent. carbon, the alloys are too hard to machine (Fig. 11, Valenta, *loc. cit.*), so a carbon content of 1.6 to 2.0 per cent. is used. Fig. 5 shows the type of needle air-heater element which is cast regularly in this alloy. These alloys are somewhat brittle when cold, but have a tensile strength of 28 tons per sq. in. The brittleness appears to be a function of the grain size, and this can be improved by careful attention to the details of melting and pouring.

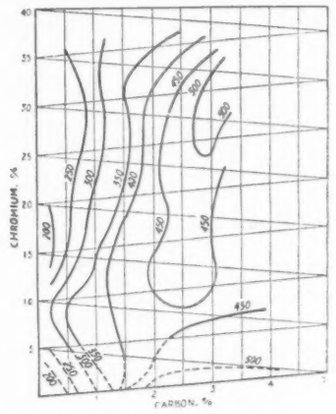


FIG. 11.—BRINELL HARDNESS OF FE-CR-C ALLOYS AS CAST.

The effect of small quantities of nickel is well marked in this direction, but at the cost of machinability. These alloys—they are ferritic—are scale-resistant up to 1,050 deg. C., but are not particularly strong at high temperatures.

The use of these alloys in annealing-furnace carriages at 850 deg. C. was marred by cracking, due partly to design and partly to the rigidity of this material. At 920 deg. C. the castings warped under load, and it was found necessary to introduce small amounts of nickel to improve the toughness (cold) and strength at high temperatures. The grain size is very much finer with 1 to 1½ per cent. nickel. The service results from these modified carriages are not yet available, but considerable improvement

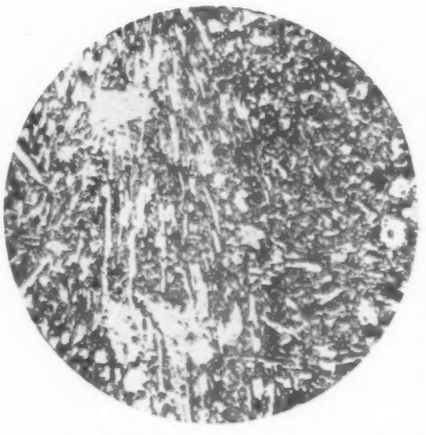


FIG. 12.—CARBIDE-FERRITE STRUCTURE OF 30 TO 35 PER CENT. CR, 1.8 PER CENT. C ALLOY, AS CAST. × 250.

seems to have been attained. It is proposed to examine the effect of nickel, tungsten, molybdenum and aluminium on the strength of these alloys at high temperatures, and for this purpose ordinary creep-test apparatus should prove suitable owing to the absence of growth. The photomicrograph in Fig. 12 shows the carbide-ferrite structure of the plain 30 to 35 per cent. Cr, 1.8 per cent. C alloy.

(*Continued on page* 490.)

Alloy Cast Irons

TYPES APPLICABLE TO STEELWORKS PLANT

A Paper by DR. A. B. EVEREST on "Alloy Cast Irons in Steelworks Plant" has recently been presented for discussion by the members of the West of Scotland Iron and Steel Institute. The Paper is published in the Journal of the Institute, from which the following extracts are taken.

Introducing the subject, DR. EVEREST states that during recent years rapid strides have been made in improving the quality of the various types of iron castings used in engineering practice. These improvements are realised to-day in the better mechanical properties now available, allowing on the one hand higher stresses to be imposed or, on the other, reduction in section thickness and consequently in the weight of the castings involved, whilst other properties, such as hardness, density and quality of finish have all played their part in improving life and service. To-day alloy cast irons are in everyday production for high-duty castings and are widely adopted where improved properties are required.

The alloys most commonly used in iron castings are nickel, chromium, molybdenum, copper and aluminium, whilst abnormal proportions of such elements as silicon and manganese always found in cast iron are employed in certain types of castings. Of these additions nickel is undoubtedly the most useful, since it alone can be added in all proportions, without serious limitations.

As in alloy steels, a great many types of alloy cast irons include combinations of the various additions, but the greater proportion of these include nickel as one constituent. The most common types are those involving the use of nickel alone, nickel-chromium, nickel-chromium-molybdenum, and special compositions with nickel, copper, chromium and molybdenum either singly or in combination. These various combinations have led to a series of alloy cast irons, many of which now find service in steelworks plants

The following extracts from the Paper relate to the chief types suitable for steelworks use.

Low-Alloy Cast Iron

This group includes cast irons of controlled composition alloyed with small proportions of nickel, copper or chromium in order to effect control over the structure of the metal. The influence of nickel in this class of iron is to give a refined structure which is maintained uniformly throughout varying sections. Thus, in a casting involving thick and thin sections the addition of nickel ensures ready machinability in the thinner parts, which might otherwise tend to be hard and chilled, whilst at the same time it ensures density, soundness and high strength in the thick parts, which frequently are subjected to the higher duties in service, as for example in most types of engine block castings. Nickel-chromium additions are also frequently used to give improved structures with good wearing quality, whilst combinations including molybdenum are employed where additional strength and toughness, over and above that conferred by the other alloy additions, are required.

In this class fall also certain special process irons, as for example "Ni-Tensyl" iron, which is a synthetic material made up mainly from steel scrap and which is alloyed with nickel and inoculated with silicon in order to give a controlled structure of abnormally high strength and other mechanical properties. It is irons of this class which have enabled the specifications for iron castings to be raised until strengths over 22 tons per sq. in. are to-day standard.

An important series of alloy cast irons developed for heat-resisting applications is that containing small proportions of chromium. In virtue of its action in stabilising the carbides, chromium is useful in small as well as in large proportions for conferring stability in castings for use, for example, in furnace construction. Chromium alone, however, tends to make cast iron hard and somewhat brittle, and it is for this reason that many of the low-alloy types to-day contain chromium in conjunction with nickel. It might incidentally be mentioned that special heat-resisting castings are now in production with chromium as high as 30 per cent., and such castings have given good service, although their production presents special problems to the foundry.

Heat-Treatable Cast Iron

The use of alloy additions in cast iron has opened up the whole field of heat-treatment as applied in the case of steels. Substantial improvements in hardness and wearing quality on the one hand and of strength on the other are achieved by different degrees of heat-treatment. As in the case of steels, nickel is one of the most valuable elements in this connection owing to its influence in lowering the temperature of the critical points, but more important in lowering the critical speed of quenching so that full response may be obtained by means of an oil quench or by air cooling according to the proportion of alloy present. This has eliminated the hazard previously associated with the heat-treatment of ordinary cast iron, in which the water quenching necessary, more often than not, led to failure or at least to incipient cracking. By means of various combinations of quenching and tempering treatment, irons with fully martensitic or sorbitic structures are developed to-day.

A special section under this heading deals with the low-alloy white iron "Ni-Hard." It is well known that white cast iron consists structurally of massive carbide crystals in a pearlitic matrix. The hardness, wearing quality and strength of white iron can, however, be substantially improved by the use of alloy additions which enter the matrix of the metal. In this case again the alloy is generally a combination of nickel to control the structure, with chromium to control the degree of chill and to maintain the combined carbon, whilst molybdenum is also frequently employed to add extra toughness. The net result of these additions is to give a white iron in which the matrix is rendered martensitic, with corresponding increase in hardness and wearing quality. This iron is marketed under the name of "Ni-Hard" and is of special interest for rolls.

Austenitic Cast Irons

By means of substantial additions of alloys it is to-day possible to develop cast irons in the fully austenitic condition, giving castings with special properties in the direction of heat and corrosion resistance and being generally non-magnetic. In the case of steels the austenitic structure can be developed by various alloy additions, including especially chromium, manganese and nickel. In the cast irons, however, the first two of these elements form carbides and are therefore not helpful, except in the presence of other elements which neutralise this effect. Combinations of additions have thus been evolved, as for example nickel 10 per cent., manganese 6 per cent., giving the non-magnetic cast iron "Nomag"; nickel 14 per cent., copper 6 per cent., chromium 2 per cent., giving the heat and corrosion resisting cast iron "Ni-Resist"; and nickel 18 per cent., chromium

(*Continued at foot of third column.*)

Transcription of the Names of Slav Authors

PROF. A. PORTEVIN, in a note which he has contributed to "Revue de Metallurgie," points to the difficulty of correctly transcribing the names of authors of Slavonic origin. Some confusion can be avoided by a knowledge of their origin, and he suggests that the following should be appreciated.

(1) Slav names are initially written in their original language in Cyrillic characters or Slavonic derived from Greek (Russian, Ukrainian, Bulgarian, Serb). Capital letters are often transcribed in other languages utilising Latin characters (English, German, French) by either transliteral or phonetic transcription. This results in the author getting his name printed in different ways; it may give the impression that there are several authors, as names will appear in diverse places in the same alphabetic lists. The following are examples relating to metallurgical authors.

Tschernoff = Chernov (English).
Tchijewsky = Tscheschewski = Cigewsky.
Ichewsky = Igewski.
Barcov = Baykoff.
Glasunov = Glazunoff.

Slav names initially written with the characters of the modified Latin alphabet and completed by diacritic signs (Polish, Greek and Slavonic) in general figure in the same style in other languages utilising the same characters but freed from their diacritic signs, but also transcribed phonetically. It sometimes happens that the name of an author of Russian origin is written in a new style if he emigrates or if he is translated from the Russian into one of these languages. The following shows two examples.

Jemtchoujny = Zemczuzny.
Fechtchenko - Tchopewski = Feszezenko-Czopiwski.

Different systems of transcriptions of Cyrillic characters are recommended or used either by the Ecole Nationale des Langues Orientales, the Royal Geographical Society or by German standardisation, etc. It is obviously desirable that unification should be established. In the meantime, it is useful for bibliographic research to be familiar with these peculiarities and to guard against possible confusion.

(*Continued from previous column.*)

2 per cent., with silicon raised to 4.5 per cent. giving "Nicrosilal," developed by the British Cast Iron Research Association as an iron of specially good heat resistance.

In addition to the above, certain special compositions are developed for particular properties, as for example irons of unusual expansion characteristics or irons possessing peculiar magnetic or electrical properties. Furthermore, there are also other types of alloy cast irons developed for special corrosion resistance and other properties not of direct interest in steelworks plant.

Applications in Steelworks

In steelworks plant many details are subject to extremely severe conditions of service, and problems of deterioration due to heat effects, to wear and tear, and to shock are frequent, and the need for high-duty materials is obvious. Although at the same time maintenance costs must be closely watched, it frequently happens that the higher cost involved in using an alloy cast iron is justified up to the hilt on account of the longer and trouble-free service given, with reduction in any liability for costly shut-down due to the failure of some component.

It can be fairly stated that wherever iron castings are used in steelworks plant, then alloy cast irons can, with profit, be considered

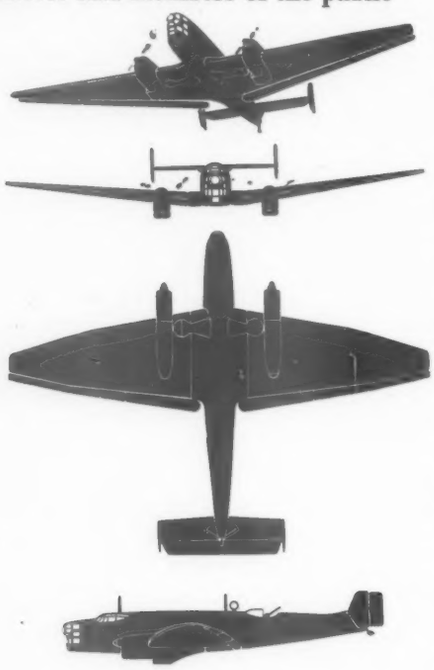
German Troop-Carrying Aeroplanes

LEARN HOW TO DISTINGUISH THEM

We have been asked by the Under-Secretary of State for War to publish the accompanying pictures showing German troop-carrying aeroplanes. They are intended to guide Local Defence Volunteers and members of the public

Junkers Ju 52.—Span 96 ft.; length 62 ft. *Distinctive features*—(i) Three engines; (ii) low wing; (iii) Single square-cut rudder; (iv) sharply tapered wings; (v) square-cut wing-tips and tail plane; (vi) fixed undercarriage.

Note: Most important German troop-carrier, and the one normally used for parachute dropping.



Junkers Ju 86.—Span 73 ft. 8 in.; length 57 ft. 4 in. *Distinctive features*—(i) Two engines; (ii) low wing; (iii) two square-cut rudders; (iv) sharply tapered wings; (v) square-cut wing-tips and tail plane; (vi) retractable undercarriage.

Junkers Ju 90.—Span 115 ft.; length 86 ft. *Distinctive features*—(i) Four engines; (ii) low wing; (iii) two rudders; (iv) tapered wings; (v) leading edge of wing has very pronounced "sweep back"; (vi) square-cut wing-tips and tail plane; (vii) retractable undercarriage.

Focke-Wulf 200 "Condor."—Span 108 ft.; length 78 ft. *Distinctive features*—(i) Four engines; (ii) low wing; (iii) single rudder; (iv) tapered wing; (v) rounded wing-tips and tail-plane; (vi) retractable undercarriage; (vii) smooth streamlined fuselage.

Control in Repetition Foundries

The prize-winning entry in the Short Paper Competition conducted recently by the East Midlands Branch of the Institute of British Foundrymen was, it will be remembered, "Control Aspects in the Repetition Foundry," by Mr. A. B. Bill (see the JOURNAL for May 2, p. 328). The Paper was afterwards discussed by the members, and their remarks are summarised below.

MR. L. SANDERS recalled the remarks about jigging cores, and suggested that with 90 per cent. of productions it would be impossible to jig them. As to faulty core boxes and faulty patterns, did not Mr. Bill think that first they affected the patternshop and secondly the core shop?

MR. BILL said he was concerned only with cores that were dimensionally important. It would be expensive to gauge every core, and such a step would naturally have to be decided in collaboration with the customer. In many cases it was usual to supply a moulder with a gauge to check his own cores, in order to prevent scrap.

The closest co-operation between the foundry and the patternshop was essential, as was stressed in the Paper. The patternshop was obviously to blame for a faulty core box sent into production. On the other hand, legitimate wear and tear of a core box might materially alter the dimensions of cores produced from it, and it was too late to rectify such an error when the castings had been made.

MR. A. DUNLEAVY said that if a foundry received an order for 3,000 or 4,000 off a pattern, the pattern and core box and the expense entailed for that pattern were divorced from the foundry. Always in foundries where large quantities of castings were made, the first question was how a casting was to be made. Who was going to reject the core if it was not correct?

Two Causes of Scrap

MR. BILL, speaking of the rejection of cores, said that, if a dimension was of sufficient importance, he thought that the core concerned should be inspected by a definite inspection department, and not by the moulder. Where the core was not particularly important, the moulder could inspect his own cores.

Mr. Bill said that the aim of every foundry was to produce perfect castings. If a moulder had to produce the largest possible number of moulds, then everything that could be controlled for him must be so. Poor sand and poor ramming seemed to him to cause as many rejects as did any other factor, and if, therefore, one could control sand and ramming, two of the chief causes of scrap would be eliminated.

Slag Inclusions

MR. P. A. RUSSELL recalled the author's statement that the bulk of rejects was due to faulty moulding. Mr. Russell's experience was that the bulk of rejects was caused by slag inclusions. Was there any method, he asked, of controlling each shank of metal to ensure that it had no pieces of slag on it? He asked for Mr. Bill's opinion upon the cause of the trouble.

MR. BILL replied that for some time he had been of the opinion that most inclusions were slag. Only a short time ago, however, he had discovered that many of what he had thought were slag inclusions were loose sand inclusions. That view had since been confirmed by several experiments. Regarding slag in shanks or ladles, it was generally accepted that strainer bushes and strainer cores should keep solid slag from a casting. Therefore, a small amount of slag in the shank should not matter. Perhaps, on the other hand, a spinner was the safest method of dealing with liquid slag.

For High Quality Castings

The increasing demand for high-strength close-grained iron castings calls for improved metal. In comparison with the accepted standards of the past, the modern high quality casting requires lower total carbon and phosphorus, with a closer range in silicon. The Ironfounder can now meet this demand at a reasonable cost by the use of Stanton-Dale Refined Pig Iron.

Stanton-Dale is a pig iron of low total carbon, the graphitic carbon being uniformly distributed and of fine curly-flake formation. The close structure ensures remarkably high strength with good machineability, and Tensiles of 16 to 20 tons can readily be obtained when a proportion of Stanton-Dale Iron is introduced.

The use of this iron avoids the irregularities in structure which are sometimes observed when steel scrap has formed part of the charge.

The correct grade of Stanton-Dale Iron to use depends on the type and class of castings to be made. The Stanton Technical Service is available to advise on suitable mixtures.

Total Carbon from 2.6 per cent. upwards. *Analysis to individual specification as required.*

STANTON-DALE
REFINED PIG IRON

The Stanton Ironworks Company Limited, Near Nottingham

***The Largest** Producers of Foundry Pig Iron (for Sale) in Great Britain*

The Week's News in Brief

Trade Talk

THE CITY ENGINEERING WORKS (1936) (PTY.), LIMITED, of Pretoria, have a new enamelling section well in hand, and it is hoped that the production of baths, etc., will begin in about two months' time.

THE POSSIBILITY of unemployed persons being trained in the workshops of technical institutions is the subject of a memorandum issued by the Board of Education to local education authorities and technical colleges.

CLEVELAND MINERS have decided to work for a larger output of ironstone. At some of the mines, the regular six hours' shift on Saturdays will be extended to eight hours. Arrangements have been made at other mines for work on Sundays, and also for extra shifts during the week.

BORAX & CHEMICALS, LIMITED, Marlyn's House, Guildford, announce that the minimum basis prices for the cheapest grades of borax and boric acid available, *i.e.*, commercial granulated, are now:—£23 per ton for borax, £37 10s. per ton for boric acid, minimum one-ton lots, carriage paid within the United Kingdom.

WE ARE INFORMED that the liquidation of Powder Metallurgy, Limited, of 101, Leadenhall Street, London, E.C.3, represents no more than a reconstruction, with the formation of a new company, Powder Metallurgy (1940), Limited, the directors of which are to be Mr. G. T. Lunt, Dr. J. E. Hurst and Dr. W. D. Jones.

THE SERVICES of Mr. J. P. Stevenson, the Coal Utilisation Joint Council's area combustion engineer in Ireland, have been loaned to the Mines Department for Government work in Scotland. The Dublin office of the Council is being closed, and communications in connection with the Council's work in Northern Ireland or Eire should be addressed to head office, General Buildings, Aldwych, London, W.C.2.

THE MINISTRY OF LABOUR is establishing three more training centres, one in Preston (Lancashire), another in Coventry, and the third in Glasgow. For the Preston centre a large building is being adapted for the training of 800 men; in Coventry a factory has been obtained which will provide 700 training places, and in Glasgow, in addition to the expansion of the existing centre, a converted factory will give space for the training of 1,000 men. The Ministry is aiming at the training of 100,000 men in a year.

THE MINISTER OF SUPPLY has decided to apply the principle of compulsion to the collection of salvage. All local authorities with populations of over 10,000 will be required to arrange efficient systems of collection, and all householders in the areas of these local authorities are to be required to co-operate in a new anti-waste campaign. Most urgently needed are scrap metals, waste paper and cardboard, and household bones. Other materials such as waste food and rags may be added to the list from time to time. Six months ago, the Ministry of Supply requested the local authorities to extend their refuse collection schemes, and there was a good response; but some Councils have not yet organised any salvage work and among those that have there is a great disparity in efficiency of the schemes operating. Under the compulsory scheme shortly to be introduced responsibility for ensuring that collection of salvage is properly organised will rest with local Councils, but provision is to be made for utilising merchants, rag-and-bone men, and voluntary organisations who have already given important help.

Contracts Open

Kilkenny—Diesel-engined air compressor, suitable for mounting on a lorry chassis, for the Kilkenny County Council. Mr. J. G. Coffey, county surveyor, Court House, Kilkenny.

Lewes, July 6—Construction of approx. 920 yds. of 12-in. dia. cast-iron rising main, for the Borough Council. Mr. C. T. Butler, borough surveyor, Town Hall, Lewes, Sussex. (Fee £2 2s., returnable.)

Pontypridd, July 10—Provision and laying of about 6,400 yds. of 6-in., 1,000 yds. of 4-in., and 15,000 yds. of 3-in. dia. cast-iron pipes, etc., for the Magor and St. Mellons Rural District Council. Thomas & Morgan & Partners, engineers, 23, Gelliwastad Road, Pontypridd. (Fee £3 3s., returnable.)

Personal

MR. J. V. S. GLASS has been awarded the William Macnab Medal for 1940 in the Associate-Membership Examination of the Institution of Chemical Engineers. There were seven successful candidates.

MR. A. A. ROWSE has resigned his appointment as Controller of Machine Tools in the Ministry of Supply. The Minister of Supply has appointed Mr. Percy Mills to be Controller and Mr. J. C. Blair to be Deputy Controller of Machine Tools in the Ministry.

MR. JAMES ROSS, assistant works manager of Dalzell Steel Works, Motherwell, has been appointed works manager in succession to Mr. D. G. Fraser. Mr. Ross went to Dalzell as welfare supervisor in 1926, and in 1935 became plate mill manager, taking over his recent post two years later.

SIR CHARLES COUPAR BARRIE, the well-known Dundee shipowner, who has been created a Baron for political and public services, is chairman of Metal Traders, Limited, and a director of the London & North Eastern Railway Company and the British Oxygen Company, Limited.

PAPER CONSERVATION AND THE EDITORIAL INDEX

In order to conserve paper, the editorial index for the current half year will not be included, as hitherto, with each copy of the Journal as a loose insert, but will be sent to readers who write to the Publisher, "The Foundry Trade Journal," 3, Amersham Road, High Wycombe, Bucks, expressing their wish to receive a copy. Please make early application in order that the correct supply may be printed.

MR. JAMES TAYLOR, of 102, Bath Street, Glasgow, who has acted for the ironworks department of Newton, Chambers & Company, Limited, in Scotland for the past 25 years, has retired, and Mr. Arnold Walters has been appointed representative for blast-furnace and steelworks plant in Scotland.

MR. DOUGLAS JEPSON, technical service and research metallurgist at Imperial Chemical Industries (General Chemicals), Limited, central laboratory, Widnes, has been appointed Lecturer in Metallurgy at Bradford Technical College from next September, to fill the vacancy caused by the resignation of Mr. H. A. MacColl.

Wills

BATES, JOSEPH, of Northwich, Cheshire, ironfounder	£31,985
BLACKADDER, PROF. WILLIAM, of the Chair of Engineering at Aberdeen University	£9,638

Obituary

MR. H. PICKUP, a director of H. Pickup, Limited, engineers and ironfounders, of Scarborough, died last week in his 81st year.

MR. J. W. MEYJES, who was formerly deputy-chairman of the Delta Metal Company, Limited, of East Greenwich and Birmingham, died recently, aged 79. He retired from business in 1928 through ill-health. He joined the company in 1889, and was secretary for some years, becoming managing director of the London branch of the business in 1907.

On Active Service

LT.-COL. J. D. BELL, R.A.O.C., has been killed on active service. He was a director of Harry F. Platt & Company, Limited, engineers' agents, of Victoria Street, London, S.W.

LT.-COL. R. H. BAKER, managing director of Kerson's Manufacturing Company, Limited, electrical accessory manufacturers and brassfounders, of Birmingham, has been killed in action.

Reports and Dividends

International Aluminium Company, Limited—Net profit for 1939, £17,417; brought in, £19,180; preference dividend, £17,374; carried forward, £19,222.

Aluminium Corporation, Limited—Profit for 1939, £44,466; brought in, £4,824; loan interest, £4,000; income debenture interest for 1934, £10,500; tax, £26,455; carried forward, £5,564.

Morgan Crucible Company, Limited—Profit for the year to March 31 last, £715,158; brought in, £362; taxes and preference payments, etc., £428,321; final ordinary dividend of 5⅝ per cent., making 8¼ per cent. for the year; to reserve, £71,934; carried forward, £825.

John Brown & Company, Limited—Profit, after providing for taxation and contingencies, in the year to March 31 last, £411,338; brought in, £163,133; final dividend of 10 per cent. on the ordinary shares, making 15 per cent. tax free; carried forward, £202,376.

Zinc Corporation, Limited—Net profit for 1939, £142,575; brought in, £57,584; transferred from profits equalisation reserve, £42,240; fixed preferential dividend, £49,138; interim participating dividend of 1s. 6d. a share, £67,412; further participating dividend of 1s. 6d., making 3s. for the year; carried forward, £58,437.

John Harper & Company, Limited—Net profit for the year ended March 26, after providing £21,798 for taxation charges, £36,148; brought in, £9,422; final dividend of 12 per cent., making 15 per cent., on the ordinary shares, £15,000; further dividend of 8 per cent. on the employees' preference shares, £591; to general reserve, £11,529; carried forward, £10,298.

Glacier Metal Company, Limited—Trading profit for year to February 29, £55,629; brought in, £9,992; depreciation, £13,545; to employees' profit-sharing scheme, £2,723; written off development, £5,148; tax, £7,850; N.D.C., £2,659; preference dividend, £5,500; to general reserve, £6,000; taxation reserve, £4,000; ordinary dividend of 7½ per cent., £7,969; carried forward, £10,317.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

B. B. H. (London), Limited—Capital £10,000. To mine, transport and smelt ores: melt, refine and alloy metals, etc. Subscriber: E. T. Remfry, 14, Woodside Road, Sutton, Surrey.

E. W. Bliss (England), Limited—Capital £150,000 in £1 shares (125,000 redeemable cumulative preference and 25,000 ordinary). Manufacturers and designers of rolling mills, presses, etc. Subscriber: London, N.W.3.

Chromium Heat-Resisting Cast Irons

(*Continued from page* 486.)

From this brief summary of the outstanding facts, the author hopes to stimulate interest in these chromium-alloy cast irons and to remove the bogey of hard spots and lack of control which have given so much trouble in the past. Chromium in small amounts is the growth-preventer *par excellence*. Chromium in large amounts is the outstanding scale-preventer. Other alloys may modify and improve other properties, but they do not improve these two special qualities of cast irons.

The author wishes to thank the general manager of the Thorncliffe Ironworks, Mr. W. T. Kitching, for permission to publish this Paper, and acknowledges with gratitude the loan of photographs of castings made in these irons by Mr. F. W. Whitehouse, foundry manager, Newton Chambers & Company, Limited. It is regretted that the Paper is not more comprehensive, but at the present time it seems to be impossible to continue some of the researches, of which the results presented in this Paper are the mere beginnings.

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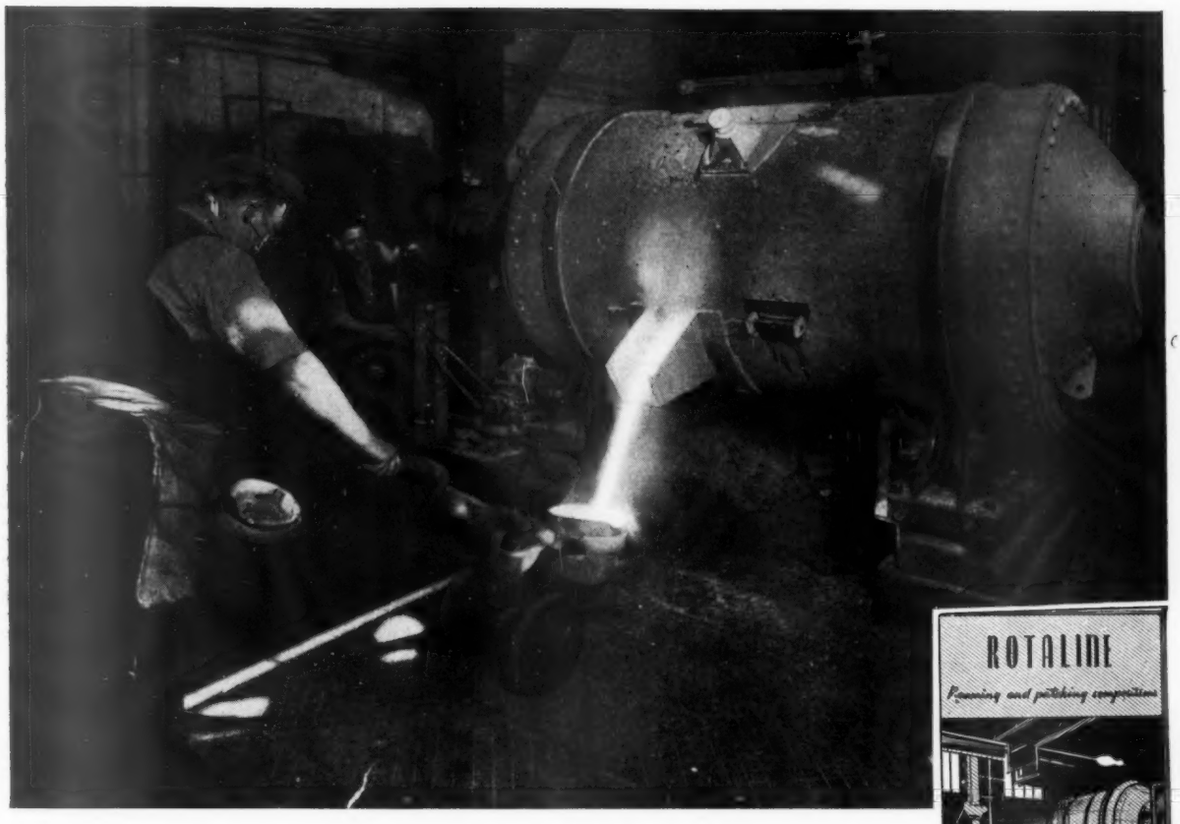
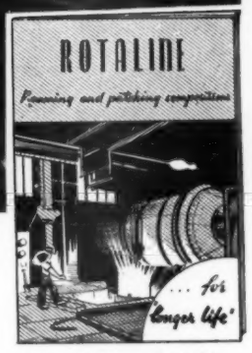
[1] Proc. Inst. Brit. Found., 1925.
[2] Journ. Iron and Steel Inst., 1936.
[3] Proc. Inst. Brit. Found., 1932–3.
[4] T. Tyrie, FOUNDRY TRADE JOURNAL, March 7, 1940.
[5] I. & S. I. Carnegie Scholarship Memoirs, vol. XIX, 1930.

for 'longer life' . . . .



A Stein & Atkinson Rotar Furnace reproduced by the courtesy of Messrs. Peglers Limited, Doncaster.



This folder — obtainable on request — gives full particulars of Rotaline and its uses. The services of our Technical Department are freely at your disposal for any further information or assistance required.

— specify

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Raw Material Markets

Light-castings foundries in some districts are now becoming more involved in the war effort as a result of adapting their plant to the manufacture of machine-tool castings and other Government requirements. But, so far, this is not general in the trade, and there continues to be idle time at many of the light foundries. Heavy engineering foundries are fully active on the production of castings for the defence programme. In the steel section of the industry, problems arising out of the new situation are being overcome. Owing to the position in the Mediterranean, it may be more difficult to obtain North African ores, but it is anticipated that shipments will continue to arrive at ports in this country, while there are several other sources of supply which could be exploited more extensively than at present.

Pig-Iron

MIDDLESBROUGH—There is increasing activity among foundries on the North-East Coast and supplies of iron are having to be distributed more carefully, in order to ensure that deliveries arrive at the destinations in greatest need. All supplies, of course, are restricted to licensed consumers, and it is difficult for users not on Government work to procure iron. No Cleveland foundry iron is now being produced and all the requirements of local consumers are satisfied by Midlands producers, who are generally able to meet inquiries. The existing position does not allow users to accumulate reserve stocks, but, on the whole, consuming plants are receiving sufficient iron to keep them in continous operation. Local steelworks are taking up a large proportion of the output of East Coast hematite, and the surplus is readily accepted by consumers in Sheffield and the Midlands, so that makers' stocks are negligible. Consumption is expanding as the armaments drive gathers momentum.

LANCASHIRE—Derbyshire and other makers of foundry iron used in this area are concentrating their attention more and more on the production of steel-making iron, so that the tonnage available for consumers in the local ironfoundry trade is rather less. Apart from the light-castings trade, the demand for pig-iron is maintained and the control of distribution is being tightened. Jobbing foundries are moderately well employed and their position is improving, but light foundries generally are still only intermittently engaged, as there is little in the nature of Government work available for this section at the present time. Deliveries of West Coast hematite are satisfactory to meet an increasing demand.

MIDLANDS—As has been the case for a considerable time past, the heaviest consumption of iron in the Midlands engineering industry is among the works on munitions production, and for this low-phosphorus iron and hematite are the main descriptions used. Consumers are operating to capacity and the call for these grades is thus expanding weekly. As yet, users are obtaining adequate supplies to enable them to maintain operations, but the position is having to be closely watched, as production of both hematite and low-phosphorus iron is barely sufficient to meet requirements. Furnaces have little or no stock on hand and an early increase in output is being planned. Larger production of high-phosphorus basic iron has resulted in the transfer of some furnaces formerly making foundry grades to basic iron, with a consequent falling away in the supply of foundry iron. Consumption of the latter is not heavy, but the distribution of supplies is now being carried out with greater care. The chief user of high-phosphorus foundry iron is the light-castings industry, which is still only moderately employed, but a small quantity is also required by heavy engineering concerns. Iron for ordinary domestic purposes is difficult to procure and will be more so henceforth, but the Control authorities are allocating certain tonnages for use in export trades.

SCOTLAND—Government work for the Falkirk light-castings trade appears to be coming to hand more freely, but there is still much room for improvement in this respect before producers have order-books sufficiently well filled to enable them to operate a full-time schedule. Heavy engineers, of course, continue to be very busy. Government requirements accounting for the total output of most plants. Deliveries of iron are coming forward fairly satisfactorily, but the output of an additional furnace which has recently been blown in will nevertheless be welcomed. Hematite is in good demand.

Coke

Many consumers of foundry coke are covered by contracts over several months ahead, and the position is satisfactory. Ovens are making deliveries on a good scale, and there is every reason to anticipate a continuance of this service. The policy of users to build up stocks, however, is a wise precaution against possible interruptions of supplies in the future. Forward contracts are based on payment of the price ruling at the time of delivery. The present quotation is 55s. 6d. per ton, delivered to Birmingham and Black Country stations, but this figure may be revised at any time by the Control authorities.

Steel

Supplies of steel to supplement production at home are assured by the decision of the United States Government to place the industrial resources of America at the disposal of the Allies. While this is comforting and may be of increasing importance in the future, it is hoped that the production of works in the United Kingdom will be able to meet the bulk of the requirements. Deliveries of steel semis from America, necessary now that Belgian sources have dried up, are coming through satisfactorily. As a result, re-rollers are able to be kept in operation continuously. The demands upon the British steel industry at the present time are at a record level, but output, too, is higher than it has ever been in the history of the trade, and there is every cause for gratification at the way in which works have responded to wartime needs.

Scrap

Since the formation of the new Government the scrap collection campaign has been intensified through the steps taken by Mr. Herbert Morrison and the Ministry of Supply, but it is still felt that a greater tonnage should be forthcoming, and it seems probable that the Ministry will exert its powers to enforce the placing of all old metal at the disposal of the State. It is understood that all local authorities with populations of more than 10,000 must arrange efficient systems of collection of metal and other waste commodities in future. The consuming works are feeling the benefit of the tremendous efforts already made in some parts of the United Kingdom, but in the circumstances all the scrap iron and steel lying idle must be brought into the furnaces to aid the steel production movement. Merchants are busier than they have been for a long time past, while voluntary collections are resulting in substantial sums of money being made available for various charities. Local authorities are playing a vital part in the scrap campaign and, in addition to providing facilities for actual collections, many are turning out supplies from their own property. Replying to a question in the House of Commons on Thursday last, Mr. Harold Macmillan, Parliamentary Secretary to the Ministry of Supply, said that although the scheme launched through the rural district councils for the collection of scrap metal in central dumps had only been in operation for 10 days, about 1,000 offers of co-operation had already been received.

Metals

The French situation has again been reflected in the trend of tin prices on the London Metal Exchange. There was a resumption prior to the week-end of large-scale buying on American account, most of the business being for prompt or early deliveries. Higher prices in London resulted, but the publication of the terms of the armistice subsequently reacted unfavourably on the market. Consumption of tin in the United Kingdom is maintained at record levels, and is expected further to expand in accordance with the greater production of the munitions factories. In the United States, the tinplate mills are operating at around 75 per cent. of capacity, and tin consuming industries generally are likely to be more fully employed as sympathy for the Allied cause is transmuted into material assistance, while the American home defence proposals will mean the consumption of a considerable tonnage of the white metal. The suggestion that fixed prices for tin and rubber might be introduced in America if war continued beyond the current year, even if the United States did not become a belligerent country, was made recently by Mr. George A. Reanard, secretary of the National Association of Purchasing Agents in America, on the grounds that unless artificial and unnecessary advances to prices were restrained by good business sense, prices would be controlled by the Government.

London Metal Exchange tin prices this week have been as follow:—

Cash—Thursday, £272 to £272 10s.: Friday, £274 5s. to £274 15s.; Monday, £266 to £266 10s.; Tuesday, £261 10s. to £262; Wednesday, £256 to £257.

Three Months—Thursday, £275 to £275 10s.; Friday, £278 to £278 5s.; Monday, £269 5s. to £269 10s.; Tuesday, £265 10s. to £266; Wednesday, £258 15s. to £259.

The subject of outstanding French copper contracts with United States producers has yet to be clarified. The London Chamber of Commerce has sent a communication to members of the London Metal Exchange regarding products sold to the French Government for which payment has not yet been made. The Chamber proposes that representations should be made to his Majesty's Government on behalf of all trades concerned. It seems likely that Britain will take over a proportion at least of the copper orders, but it is uncertain whether this country will assume responsibility for all unpaid French contracts. It is quite possible that the armistice negotiations between the Bordeaux Government and Germany may have involved certain decisions on such matters, but if so the verdict has yet to be divulged. Consumption of copper in the United States is on a steadily increasing scale, large tonnages being absorbed in the armament works both on home defence and Allied accounts.

Interesting data regarding the Chilean copper industry are given in the monthly report of the Banco Central de Chile, which states that production in the first two months of the year, although lower than the December, 1939, output, which reached 36,841 tons, was well up on the corresponding months of last year. Production in January of this year was 34,907 tons, against 25,852 tons in January, 1939, and in February 33,893 (25,417) tons.

Supplies of spelter from various Empire sources continue to arrive at United Kingdom ports, but a possible outcome of the Italian entry into the conflict is that this country will have to rely on a certain amount of American metal being made available. At present, with metal restricted for use by non-essential industries, supplies for munitions are being well maintained. The lead supply position is quite satisfactory, metal being spared for domestic users and for the export of lead products after requirements of Government contracts have been met.

Trading in non-ferrous metal scrap remains restricted, demand generally being still at a low ebb.

Applications for Trade Marks

The following list of applications to register trade marks has been taken from the "Trade Marks Journal":—

"BROOZINC"—Aluminium-zinc alloys. BROOKSIDE METAL COMPANY, LIMITED, Astra Works, Harland Estate, Honeypot Lane, Stanmore, Middx.

"DURASEAL"—Metal packings for moving parts of machinery. DURAMETALLIC CORPORATION, c/o Frank B. Dehn & Company, Kingsway House, 103, Kingsway, London, W.C.2.

"DURAK"—Zinc base alloys for use in die-casting. NATIONAL ALLOYS, LIMITED, Sandroyd, Sandy Lane, Cobham, Surrey.

"SELECTRO"—Screening, separating sorting and grading machines. HEAD, WRIGHTSON & COMPANY, LIMITED, Teesdale Iron Works, Trafalgar Street, Thornaby-on-Tees.

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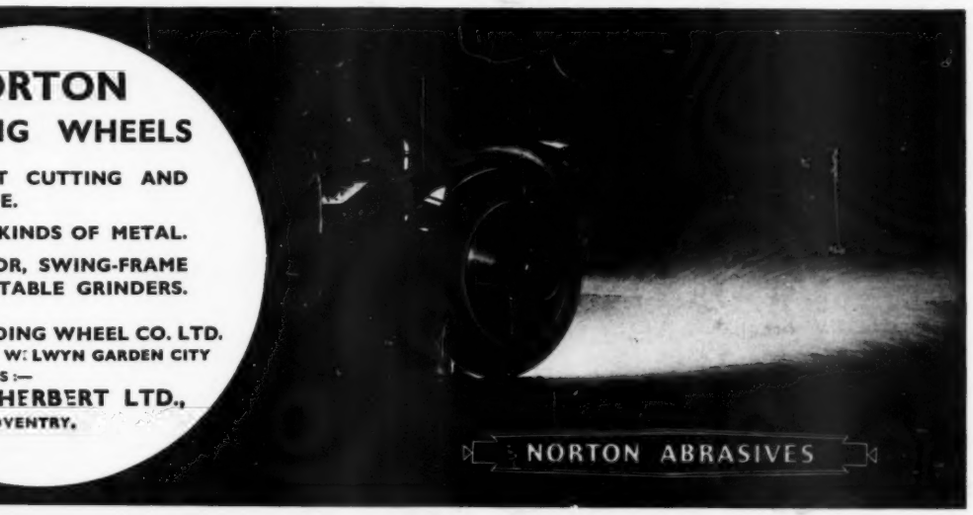

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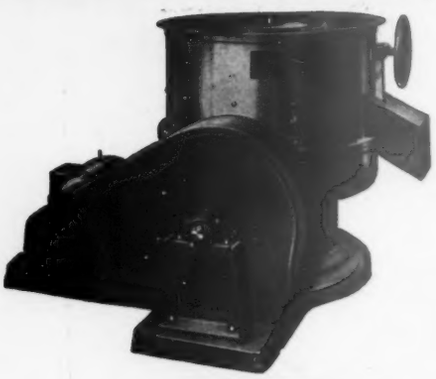

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AN EXAMPLE OF UNPARALLELED SIMPLICITY

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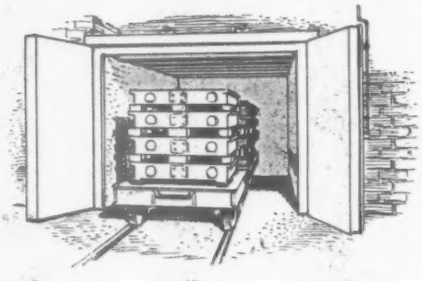
CORE  STOVE

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The Kilns,
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OUR REF JHF/1286.
DATE 16th November 1939.

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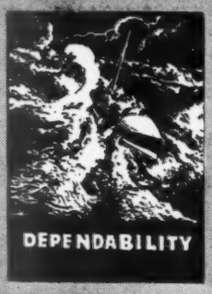

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244	2·83	1·88	0·78	0·060	0·41	20·00	20·02	8·52	242
245	3·21	1·32	1·01	0·062	0·28	22·10	17·70	10·02	232
251	3·00	2·35	1·20	0·038	0·19	17·95	15·10	7·96	232
261	2·56	2·11	1·08	0·052	0·66	19·50	20·80	9·31	228
262	2·67	1·57	0·62	0·048	0·35	20·60	19·92	17·22	228
358	3·00	1·90	1·05	0·038	1·01	20·90	17·45	8·63	232
373	3·00	1·39	0·92	0·056	0·25	20·70	17·20	15·50	252
376	3·05	2·02	1·03	0·060	0·39	19·30	16·85	15·11	228
386	2·67	1·95	0·96	0·058	0·25	19·77	22·60	15·75	218
426	2·73	2·19	1·04	0·056	0·41	18·70	16·08	18·30	228
428	3·21	2·11	1·12	0·060	0·32	17·60	17·55	16·18	217
429	3·00	2·11	1·27	0·060	0·20	21·20	17·90	15·59	228
442	2·89	1·69	1·00	0·056	0·29	19·20	15·90	14·80	241
445	2·65	2·25	1·05	0·058	0·17	17·21	17·25	7·56	255

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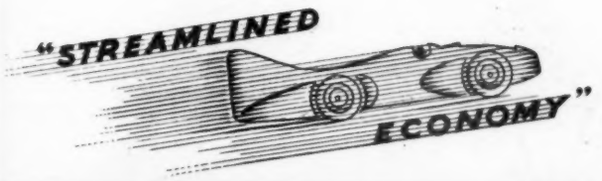

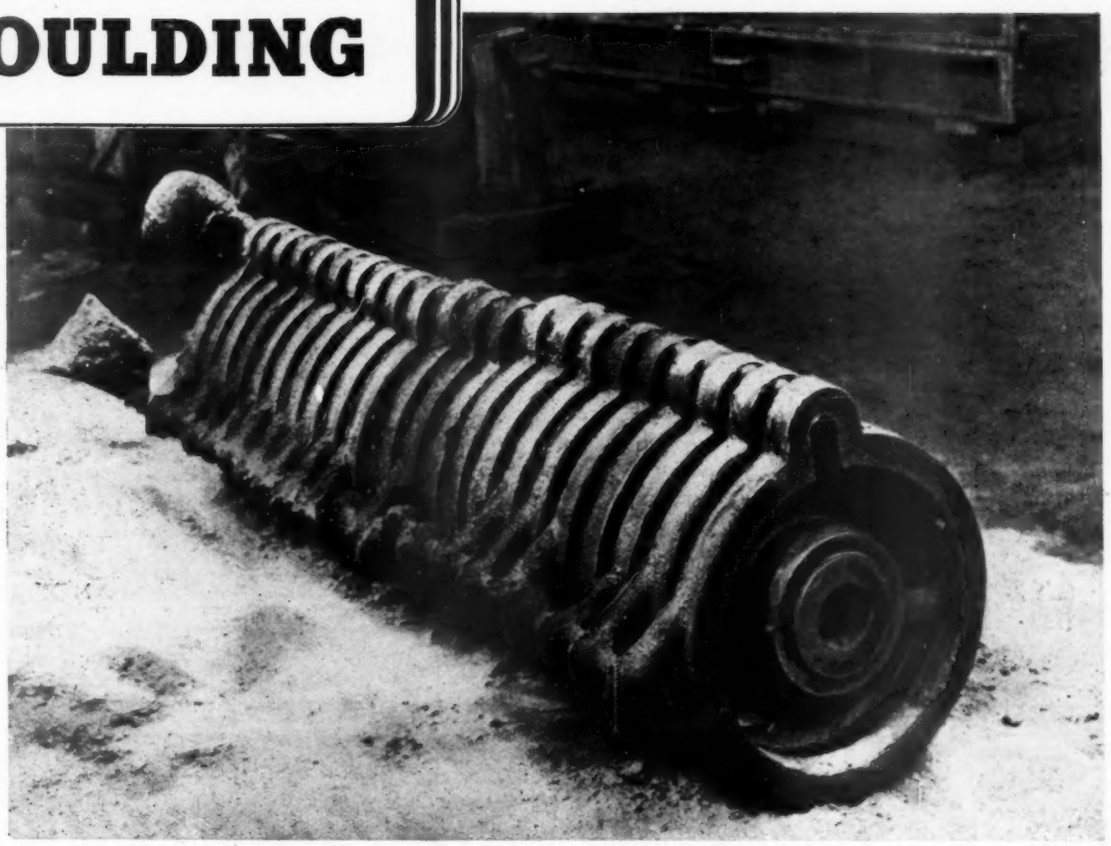

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Climax Rock Drill & Eng. Works, Ltd.	—
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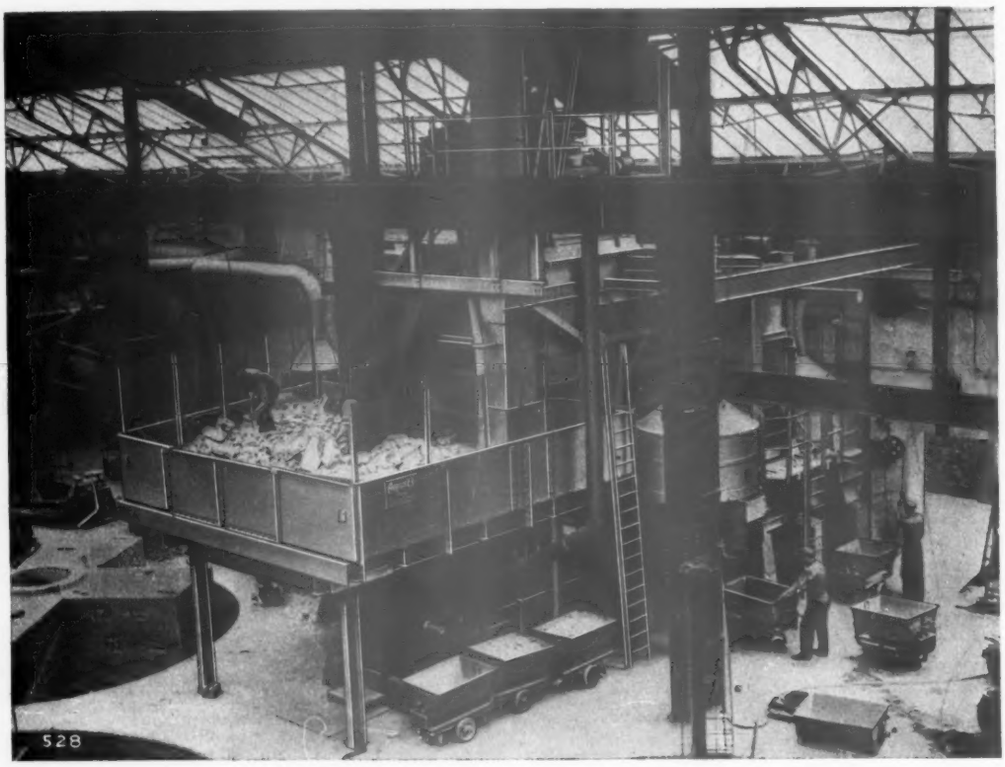
Coggon, Harry F., & Co.	—
Colvilles, Ltd.	—
Consett Iron Co., Ltd.	—
Constructional Engineering Co., Ltd., The	13
Copper Development Association	—
Core Oils, Ltd.	—
Corn Products, Ltd.	9
Cumming, Wm., & Co., Ltd.	—
Davidson & Co., Ltd.	13
Distington Hematite Iron Co., Ltd., The	—
District Chemical Co., Ltd.	—
Durrans, James, & Sons, Ltd.	17
Durrans, John & C.	—
Easton & Johnson, Ltd.	24
Electric Furnace Co., Ltd.	—
Electromagnets, Ltd.	—
Ether, Ltd.	18
Every, Hy., & Co., Ltd.	—
F. & M. Supplies, Ltd.,	17
Findlay, A., & Co., Ltd.	—
Fordath Engineering Co., Ltd.	2
Foundry & Engineering Co. (West Bromwich), Ltd.	—
Foundry Equipment, Ltd.	—
Foundry Plant & Machinery, Ltd.	6
Foundry Services, Ltd.	—
Fry's Metal Foundries Ltd.	—
Gadd, Thos.	—
General Electric Co., Ltd., The	19
General Galvanizers, Ltd.	—
General Refractories, Ltd.	491
Gibbons Bros., Ltd.	—
Gossell. & Son, Ltd.	—
Gray, Thos. E., & Co. Ltd.	20, 23 & 24
Green, George, & Co.	—
Guest Keen Baldwins Iron & Steel Co., Ltd.	—
Hammond, Alex.	16
Harper, Wm., Son & Co. (Willenhall), Ltd.	24
Harrison & Son (Hanley) Ltd.	—
Hawkins W. T. & Co.	—
Herbert, Alfred, Ltd.	1
Heywood S. H. & Co., Ltd.	20
Hill-Jones, Thos., Ltd.	—
Imperial Chemical Industries, Ltd.	—
Incandescent Heat Co., Ltd.	—
International Alloys, Ltd.	5
Jackman, J. W., & Co., Ltd.	—
Jacks, William & Co., Ltd.	15
Keith Blackman, Ltd.	11
King Bros. (Stourbridge), Ltd.	22
King, Taudevin & Gregson, Ltd.	—
Lafarge Aluminous Cement Co., Ltd.	4
Laidlaw Drew & Co. Ltd.	—
Lempriere & Co. Pty. Ltd. O.T.	—
Lloyd, F. H. & Co., Ltd.	—
Lord, E. S., Ltd.	23
Luke & Spencer, Ltd.	—
Macnab & Co., Ltd.	—
Major, Robinson & Co., Ltd.	24
Mansfield Standard Sand Co., Ltd.	—
Marco Conveyor & Engineering Co. Ltd.	—
Mavor & Coulson Ltd.	—
Metropolitan-Vickers Electrical Co., Ltd.	18
Midland Monolithic Furnace Lining Co., Ltd., The	—
Mirrlees, Bickerton & Day, Ltd.	22
Mirrlees Watson Co., Ltd., The	—
Molineux Foundry Equipment, Ltd., W. J.	23
Mond Nickel Co., Ltd., The	—
Multiple Acting Flux Ltd.	1
National Savings Committee, The	—
Neild, G.	24
Newman Hender & Co., Ltd.	—
Norton Grinding Wheel Co., Ltd.	1
Notcutt, Walter P., Ltd.	—
Olsen, Wm., Ltd.	—
Paterson Hughes Engineering Co., Ltd.	23
Pearson, E. J. & J., Ltd.	23
Pickerings, Ltd.	—
Pickford, Holland & Co., Ltd.	—
Pneulec, Ltd.	7
Portway, C., & Sons	—
Precision Presswork Co., Ltd.	—
Price J. T., & Co., Ltd.	—
Rapid Magnetting Machine Co., Ltd	16
Reavell & Co., Ltd.	—
Richardson, R. J., & Son, Ltd.	—
Ridsdale & Co., Ltd.	—
Riley Stoker Co., Ltd.	—
Robson Refractories, Ltd.	—
Roper, E. A., & Co.	—
Rowland, F. E., & Co., Ltd.	—
Rustless Iron Co., Ltd., The	22
St. George's Engineers, Ltd.	17
Safety Products, Ltd.	—
Sheepbridge Coal & Iron Co., Ltd.	—
Smith, Albert, & Co.	22
Smooth-On Mfg. Co.	—
Spermolin, Ltd.	—
Stanton Ironworks Co., Ltd., The	489
Staveley Coal & Iron Co., Ltd	—
Steele & Cowlishaw	—
Stein & Atkinson, Ltd.	—
Stein, J. G., & Co., Ltd.	—
Sterling Foundry Specialties, Ltd.	—
Sternol, Ltd.	10
Stewarts and Lloyds, Ltd.	—
Suffolk Iron Foundry (1920), Ltd.	—
Tallis, E., & Sons	—
Telsen, Th.	—
Thermic Equipment & Engg. Co., Ltd.	—
Thomas, G. & R., Ltd.	—
Tilghmans Air Compressor Co.	21
Tilghman's Patent Sand Blast Co., Ltd.	—
Tools & Drawing Dies Ltd.	—
United Steel Companies, Ltd., The	—
Universal System of Machine Moulding & Machinery Co., Ltd.	—
Vaughan, Jones & Co.	16
Vickers-Armstrongs, Ltd.	—
Walker, I. & I.	25
Ward, Thos. W., Ltd.	1, 16 & 26
Waring Bros.	—
Warner & Co., Ltd.	—
Watson's (Metallurgists), Ltd.	22
Wengers, Ltd.	—
West Midland Refining Co., Ltd.	—
Wheatsoe Foundry & Engineering Co., Ltd.	—
Wilfley Mining Machinery Co., Ltd., The	—
Wilkinson, Thos., & Co., Ltd.	—
Woodward Bros. & Copelin, Ltd.	—
Workington Iron & Steel Co. (Branch of The United Steel Companies Ltd.)	—

August's



An August's Sand Reclamation and Preparation Plant for the Randupson Process.

Courtesy of Manganese Bronze and Brass Co. Ltd.

Recent progress in Scientific Control of Founding Processes is not confined to the Iron and Steel branches of the industry—the non-ferrous foundries are very alive to modern advances too.

August's are assisting in these developments; J. Stone & Co., Ltd., Magnesium Castings & Products Ltd., Shipham & Co., Ltd., John Holroyd & Co., Ltd., amongst other well-known non-ferrous founders are installing August's mechanisation.

"The Specialists in Foundry Mechanisation"

whose products

"Set the Standard by which Foundry plant is judged."

August's

LIMITED

'Phones: 61247 & 8. HALIFAX, ENGLAND 'Grams: August, Halifax

Sole Licensees and manufacturers for British Empire (excluding Canada) of the Simpson Sand Mixer

...TRADE... SIROCCO ...MARK...

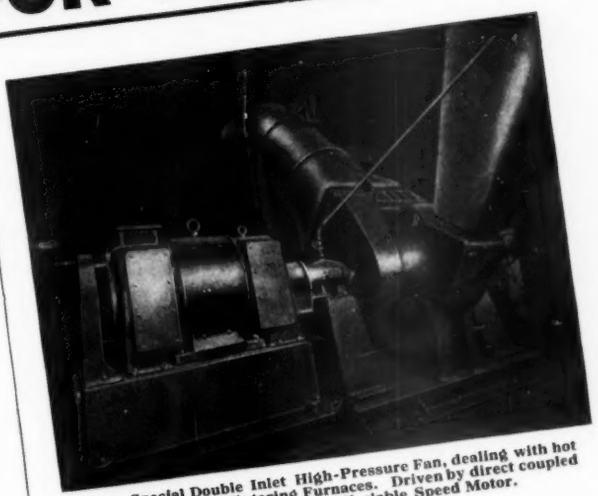
High-Pressure FANS FOR FOUNDRIES

- FORGE FANS
- CUPOLA FANS
- STEEL PLATE FANS

"Sirocco" High Pressure Fans have been designed for the comparatively high pressures which are necessary in connection with the supply of air blast to Forges and Cupolas, or for work of a similar character. The Fans are soundly constructed to give hard and continuous service with a minimum of attention.

MANUFACTURED IN A WIDE RANGE OF SIZES AND DESIGNS

Write for a copy of Publication Ref. SF 26



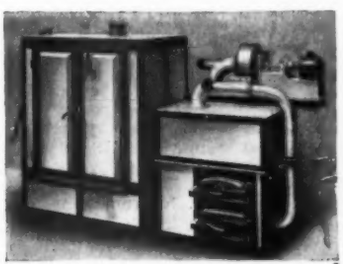
50-ins. Special Double Inlet High-Pressure Fan, dealing with hot gases from Spelter Sintering Furnaces. Driven by direct coupled 110 B.H.P. 440 Volt. D.C. Variable Speed Motor.

DAVIDSON & CO., LTD., SIROCCO ENGINEERING WORKS, BELFAST
LONDON · MANCHESTER · GLASGOW · NEWCASTLE · BIRMINGHAM · CARDIFF · DUBLIN · BRISTOL

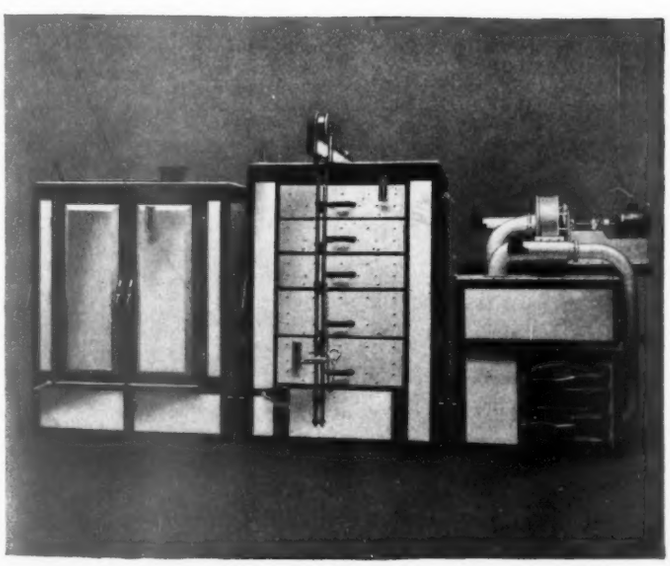
Almost 60 years' experience is behind the trade mark "SIROCCO"

Bomb and Grenade Production demands

HIGHEST CORE-QUALITY with MAXIMUM CORE-DRYING OUTPUT



The coke-fired "Korex" Tray Cabinet Type Stove with single cabinet will handle the output of
10 Coremakers



The coke-fired Combination "Korex" Tray Type and "Superkor" Drawer Type Core Stove will handle the output of
20 Coremakers

INSTALL A TITAN PORTABLE CORE STOVE

THE CONSTRUCTIONAL ENGINEERING Co LTD
Titan Works, Birmingham, 12.
Tel. MID. 4753-4 **Telegrams "Structural"**

RAW MATERIALS—PRICE LIST

Wednesday, June 26, 1940

COPPER*

	£	s.	d.
Electrolytic	62	0	0
High-grade fire-refined	61	10	0
Fire-refined of not less than 99.7 per cent.	61	0	0
Do., do., 99.2 per cent.	60	10	0
Black hot-rolled wire rods	65	10	0

TIN

Standard cash	256	0	0
Three months	258	15	0
Settlement	256	10	0

SPELTER*

G.O.B. (foreign) (duty paid)	25	15	0
Do. (domestic)	26	10	0
"Prime Western"	26	10	0
Refined and electrolytic	27	5	0
Not less than 99.99 per cent.	28	15	0

LEAD*

Good soft pig lead (foreign) (duty paid)	25	0	0
Do., do., (Empire and domestic)	25	0	0
English	26	10	0
Sheets, home	34	10	0
Do. export, f.o.b.	30	0	0
Pipes, home	34	0	0
Do. export, f.o.b.	30	10	0
Tea lead (nom.)		—	

ALUMINIUM

Ingots	£110
Wire, 10g.	£120
Sheets	1/2½ to 1/4½
Circles, 20/24g.	1/3 to 1/4

ZINC SHEETS, etc.

Sheets, 10g. and thicker, ex works	39	2	6
Rolled zinc (boiler plates), ex works	37	2	6
Zinc oxide (Red Seal), d/d buyers' premises	28	7	6

ANTIMONY

English	106	0	0			
Foreign Regulus, duty paid	99	0	0			
Chinese, prompt shipment, c.i.f.	82	0	0	to	86	0	0

QUICKSILVER

Quicksilver, ex-w'hse London	55	0	0	to	57	0	0

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 0d.
Finished bars, 18% tungsten	3s. 10d.
Finished bars, 22% tungsten	4s. 4d.

Per lb. d/d buyers' works.

NICKEL SILVER, etc.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
to 10g.	1/6½ to 2/1½

with extras according to gauge.

Special 5ths quality turning rods in straight lengths, 1/5½ upwards.

* Maximum prices per long ton delivered to buyers' premises.

FERRO-ALLOYS AND STEEL-MAKING METALS

(all prices nominal)

Ferro-silicon—	£ s. d.
25%	18 10 0
40/50%	21 10 0
75%	31 0 0
Ferro-vanadium—	
35/50%	15/6 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	6/- lb. Mo.
Ferro-titanium—	
20/25% carbon-free	1/9 lb.
Ferro-tungsten—	
80/85%	5/1 lb.
Tungsten metal powder—	
98/99%	5/2½ lb.
Ferro-chrome—	
2/4% car.	—
4/6% car.	42 0 0
6/8% car.	42 0 0
8/10% car.	—
Ferro-chrome— •	
Max. 2% car.	1/0½ lb. Cr.
Max. 1% car.	1/1¼ lb. Cr.
Max. 0.5% car.	1/1½ lb. Cr.
70% carbon-free	1/3 lb. Cr.
Nickel—99.5/100%	£190 to £195
"F" nickel shot	175 0 0
Ferro-cobalt, 98/99%	8/9 lb.
Metallic chromium—	
96/98%	3/9 lb.
Ferro-manganese—	
76/80% loose	17 11 0
76/80% packed	19 1 0
Metallic manganese—	
94/96% carbon-free	1/9 lb.

Per ton unless otherwise stated, basis 2-ton lots, d/d Sheffield works.

SCRAP*

	£ s. d.	£ s. d.
SOUTH WALES—		
Short heavy steel, not ex. 24-in. lengths	3 16 6	to 3 19 0
Heavy machinery cast iron	4 6 6	
Ordinary heavy cast iron	4 1 6	
Cast-iron railway chairs	4 6 6	
Medium cast iron	3 17 9	
Light cast iron	3 13 0	
MIDDLESBROUGH—		
Short heavy steel	3 14 3	to 3 16 9
Heavy machinery cast iron	4 11 3	
Ordinary heavy cast iron	4 8 9	
Cast-iron railway chairs	4 8 9	
Medium cast iron	3 19 0	
Light cast iron	3 14 0	
BIRMINGHAM DISTRICT—		
Short heavy steel	3 9 3	to 3 11 9
Hematite ingot mould	5 10 9	
Heavy machinery cast iron	4 11 9	
Ordinary heavy cast iron	4 7 0	
Cast-iron railway chairs	4 7 0	
Medium cast iron	3 19 9	
Light cast iron	3 14 9	
SCOTLAND—		
Short heavy steel	3 14 0	to 3 16 6
Heavy machinery cast iron	4 13 9	
Ordinary heavy cast iron	4 8 9	
Cast-iron railway chairs	4 13 9	
Medium cast iron	3 16 9	
Light cast iron	3 11 9	

* Delivered free to consumers' works in England and Wales. For deliveries of cast-iron scrap free to consumers' works in Scotland, the above prices less 3s. per ton, but plus actual cost of transport or 6s. per ton, whichever is the less. All prices: Plus 2½ per cent. dealers' remuneration: 50 tons and upwards over three months 2s. 6d. extra.

PIG-IRON*

N.E. COAST (d/d Tees-side area)—	
Foundry No. 1	114/-
„ No. 3	111/-
„ No. 4	110/-
Forge No. 4	110/-
Hematite No. 1	127/6
Hematite M/Nos.	127/-
N.W. COAST—	
Hem. M/Nos. d/d Glas.	127/6
„ d/d Birm.	139/-
MIDLANDS (d/d Birmingham dist.)—	
Staffs No. 4 forge	112/-
„ No. 3 fdry.	113/-
Northants forge	109/6
„ fdry. No. 3	110/6
„ fdry. No. 1	113/6
Derbyshire forge	112/-
„ fdry. No. 3	113/-
„ fdry. No. 1	116/-
Phosphorus 0.5% to 0.75%	120/6
Phosphorus 0.1% to 0.5%	129/-
SCOTLAND—	
Foundry No. 1, f.o.t.	115/-
„ No. 3, f.o.t.	112/6
Cleveland No. 3, Glasgow	114/-
„ „ Falkirk	111/-
Scottish hem. M/Nos. d/d	127/6
SHEFFIELD (d/d district)—	
Derby forge	109/6
„ fdry. No. 3	110/6
Lincs forge	110/6
„ fdry. No. 3	110/6
W.C. hematite	133/-
LANCASHIRE (d/d eq. Man.)—	
Derby fdry. No. 3	116/-
Staffs fdry. No. 3	116/-
Northants fdry. No. 3	114/6
Cleveland fdry. No. 3	116/-
Cylinder and Refined Irons	
North Zone	159/-
South Zone	161/6
Refined Malleable	
Birmingham and S. Staffs	156/6
Cold Blast	
South Staffs	205/-

* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms and Slabs.

BASIC:	£ s. d.
Soft, u.t., 100-ton lots	9 7 6
Tested, up to 0.25% C.	9 12 6
Tested, 0.25 to 0.33% C.	9 15 0
Tested, 0.33 to 0.41% C.	9 17 6
Hard (0.42 to 0.60% C.)	10 10 0
„ (0.61 to 0.85% C.)	11 0 0
„ (0.86 to 0.99% C.)	11 10 0
„ (1% C. and up)	12 0 0
Silico-manganese	13 2 6
Free-cutting	11 2 6
SIEMENS MARTIN ACID:	
Up to 0.25% C.	12 7 6
Case-hardening	13 5 0
Silico-manganese	13 2 6

Billets, Blooms and Slabs for Forging and Stamping.

Basic soft, up to 0.25% C.	11 0 0
Basic hard, 0.42 to 0.60% C.	11 7 6
Acid, up to 0.25% C.	12 17 0

Other Semi-products, etc.

Tin bars	9 5 0
Sheet bars	9 5 0
Wire rods, soft basic	13 15 6*
„ hard basic	16 18 0*
„ free-cutting	15 18 0
„ acid	20 9 0

* Subject to rebate.

FINISHED STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel bars, sections, plates joists and hoops is obtainable in the home trade under certain conditions.]

	£	s.	d.
Plates, ship, etc.(N.E. Coast)	12	10	6
Boiler plts. (N.E. Coast)	13	8	0
Chequer plts. (N.E. Coast)	14	0	6
Angles, over 4 un. ins.	12	8	0
Tees, over 4 un. ins.	13	8	0
Joists, 3 in. × 3 in. and up	12	8	0
Rounds and squares, 3 in. to 5½ in.	13	8	0
Rounds under 3 in. to ⅝ in. (untested)	14	0	0
Flats—8 in. wide and over	12	13	0
„ under 8 in. and over 5 in.	12	18	0
Rails, heavy, f.o.t.	11	3	0
Fishplates	15	10	0
Hoops	14	15	0
Black sheets, 24 g. (4 t. lots)	17	10	0
Galv. cor. shts. („)	20	16	3
Galv. flat shts. („)	21	6	3
Galv. fencing wire, 8g. plain	22	0	0

FINISHED IRON

	£	s.	d.
CROWN IRON:			
England and Wales	14	2	6
Scotland	14	2	6
Ireland, f.o.q.	14	15	0
No. 3 BARS:			
England and Wales	11	7	6
Scotland	12	10	0
Ireland, f.o.q.	12	0	0
No. 4 BARS:			
England and Wales	11	17	6
Scotland	12	15	0
Ireland, f.o.q.	12	10	0
STRIP:			
England and Wales	14	5	0
STAFFS MARKED BARS, f.o.t.	17	0	0

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated, June 6, 1940.

	Dols.
No. 2 foundry, Phila.	24.84
No. 2 foundry, Valley	23.00
No. 2 foundry, Birm.	19.38
Basic, Valley	22.50
Malleable, Valley	23.00
Grey forge, Valley	22.50
Ferro-mang., seaboard	100.00
O.-h. rails, h'y, at mill	40.00
Billets	34.00
Sheet bars	34.00
Wire rods	2.00
	Cents.
Iron bars, Chicago	2.25
Steel bars	2.15
Tank, plates	2.10
Beams, etc.	2.10
Skelp, grooved steel	1.90
Steel strip	2.10
Steel sheets	2.10
Sheets, galv., No. 24	3.50
Wire nails	2.55
Plain wire	2.60
Tinplates, 100-lb. box	85.00

COKE (at ovens)

Welsh foundry	42/6 to 44/-
„ furnace	31/6 to 33/-
Durham foundry	39/6
„ furnace	31/8
Scottish foundry	42/6 to 47/6
„ furnace	31/6

TINPLATES

f.o.b. Bristol Channel ports

I.C. cokes	20 × 14 per box		30/- to 31/-
„	28 × 20	„	60/- to 62/-
„	20 × 10	„	43/6 to 45/-
„	18¾ × 14	„	30/- to 31/-
C.W.	20 × 14	„	30/-
„	28 × 20	„	60/-
„	20 × 10	„	43/6
„	18¾ × 14	„	30/-

NON-FERROUS SCRAP

(Official Maximum Prices, per ton ex Works.)

	£	s.	d.
Bright untinned copper wire, in crucible form or in hanks	57	10	0
No. 1 copper wire	57	0	0
No. 2 copper wire	55	10	0
Copper firebox plates, cut up	57	10	0
Clear untinned copper, cut up	56	10	0
Braziery copper	53	10	0
Q.F. process and shell-case brass, 70/30 quality, free from primers	49	0	0
Clean fired 303 S.A. cartridge cases	47	0	0
70/30 turnings, clean and baled	43	0	0
Brass swarf, clean, free from iron and commercially dry	34	10	0
New brass rod ends, 60/40 quality	38	10	0
Hot stampings and fuse metal, 60/40 quality	38	10	0
Admiralty gunmetal, 88-10-2, containing not more than ½ per cent. lead or 3 per cent. zinc, or less than 9½ per cent. tin	72	0	0

NEW BRASS TUBES, etc.

	Per lb.
Solid drawn tubes	13½d.
Brazed tubes	15½d.
Rods, drawn	11½d.
Rods, extd. or rlld.	8½d.
Sheets to 10 w.g.	10⅝d.
Wire	10½d.
Rolled metal	9⅝d.
Yellow metal rods	8½d.

COPPER TUBES, etc.

Solid drawn tubes	14¾d.
Brazed tubes	14¾d.
Wire	9½d.

PHOSPHOR BRONZE

	Per lb. basis
Strip	13½d.
Sheet to 10 w.g.	13¾d.
Wire	15¾d.
Rods	15½d.
Tubes	20¾d.
Castings	17d.

Delivery 3 cwt. free.
10% phos. cop. £35 above B.S.
15% phos. cop. £40 above B.S.
Phosphor tin (5%) £40 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

AVERAGE MONTHLY PRICES OF UNMARKED BARS (SOUTH STAFFS)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1905	6 5 0	6 0 0	5 17 6	5 15 0	5 15 0	5 15 0	5 15 0	6 0 0	6 0 0	6 5 0	6 15 0	6 1 10	
1906	7 0 0	7 5 0	7 5 0	7 5 0	6 17 6	6 15 0	6 12 6	6 10 0	6 10 0	6 12 6	6 16 3	7 3 9	6 17 8
1907	7 3 9	7 5 0	7 5 0	7 5 0	7 5 0	7 7 6	7 5 0	7 7 6	7 7 6	7 7 6	7 7 6	7 5 0	7 5 11
1908	7 2 6	7 0 0	7 0 0	7 0 0	6 15 0	6 7 6	6 5 0	6 2 6	6 2 6	6 2 6	6 2 6	6 0 0	6 10 0½
1909	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 2 6	6 2 6	5 17 6	5 19 9
1910	6 2 6	6 3 4½	6 7 6	6 7 6	6 7 6	6 7 6	6 6 6	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 6 7
1911	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 12 6	6 16 6	6 7 0
1912	6 18 9	7 1 10	7 2 6	7 8 9	7 18 0	8 0 7	8 2 6	8 3 6	8 5 0	8 6 3	8 7 6	8 8 9	7 17 0
1913	8 11 6	8 10 7½	8 10 0	8 8 1½	8 2 0	8 0 0	7 17 6	7 11 6	7 8 9	7 5 6	6 18 1½	6 17 6	7 16 9
1914	6 17 6	6 15 7½	6 12 6	6 10 0	6 10 0	6 10 0	6 10 0	7 11 10½	8 0 0	7 12 6	7 5 7½	7 6 3	7 1 0
1915	7 11 6	8 5 11	8 8 9	9 6 0	10 3 2	10 19 2	11 12 6	11 13 1½	11 13 9	11 14 3	12 1 10½	13 0 9	10 6 0½
1916	13 7 6	13 10 8	13 12 9½	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 3 9
1917	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0½
1918	13 15 0	13 17 3	13 17 6	13 17 6	13 17 6	13 17 6	13 17 6	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 4 5
1919	15 10 0	16 5 0	17 15 0	17 15 0	20 15 0	21 0 0	21 0 0	22 0 0	22 0 0	22 0 0	22 7 6	22 12 6	20 1 8
1920	24 7 6	24 10 0	25 10 0	27 10 0	29 5 0	31 0 0	31 10 0	31 10 0	31 10 0	31 10 0	31 10 0	29 7 6	29 1 8
1921	26 17 3	25 0 0	23 0 0	21 0 0	19 0 0	18 5 0	16 0 0	16 0 0	15 14 0	14 0 0	13 6 8	13 0 0	19 4 5½
1922	13 0 0	12 3 9	11 14 0	11 11 10½	11 5 0	11 3 6	11 2 6	11 5 0	10 17 2½	10 16 3	10 13 0	10 12 6	11 7 0½
1923	10 16 10½	11 3 1½	12 2 6	12 8 9	12 11 6	12 1 3	11 15 11½	11 15 0	11 15 0	11 15 0	12 13 6	12 8 3	11 18 10½
1924	12 9 6	12 10 0	12 10 0	12 15 7½	12 17 6	12 17 6	12 17 6	12 17 6	12 17 6	12 14 0	12 12 6	12 12 6	12 14 8½
1925	12 12 6	12 12 6	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 4 6	11 18 6	11 13 9	11 13 0	12 6 2
1926	11 7 9½	11 5 0	11 5 0	11 5 0	11 3 9	11 3 9	11 5 0	12 0 0	13 0 0	*	15 7 6	12 19 0	12 0 2
1927	12 6 3	12 2 6	11 14 0	11 0 0	10 18 9	10 13 6	10 12 6	10 5 0	9 16 0	9 15 0	9 13 9	9 12 9	10 14 2
1928	9 12 6	9 12 6	9 11 0	9 10 0	9 8 4	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 3 6	9 1 3	9 7 9
1929	9 0 0	9 2 6	9 5 7½	9 9 4½	9 10 0	9 17 6	10 2 6	10 2 6	10 2 6	10 0 6	10 3 9	10 5 7	9 15 2½
1930	10 7 6	10 7 6	10 7 6	10 6 10½	10 6 3	10 5 0	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 4 7½
1931	10 2 6	10 0 0	10 0 0	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 16 10½	9 18 0½
1932	9 15 0	9 15 0	9 15 0	9 15 0	9 13 9	9 11 3	9 10 0	9 10 0	9 10 0	9 6 3	9 5 0	9 5 0	9 10 11½
1933	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0
1934	9 5 7	9 8 1½	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 11 6
1935	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6
1936	9 12 6	9 15 0	10 2 6	10 2 6	10 2 6	10 2 6	10 6 3	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 4 5½
1937	10 10 0	10 10 0	11 17 6	11 17 6	11 17 6	11 17 6	12 4 6	13 5 0	13 5 0	13 5 0	13 5 0	13 5 0	12 4 11½
1938	13 5 0	13 5 0	13 5 0	13 5 0	13 5 0	13 5 0	13 5 0	13 5 0	15 3 0	13 5 0	13 5 0	13 5 0	13 5 0
1939	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 15 0	12 15 0	12 6 8
1940	12 15 0	12 17 6	12 17 6	13 16 3	14 2 6	14 2 6	—	—	—	—	—	—	—

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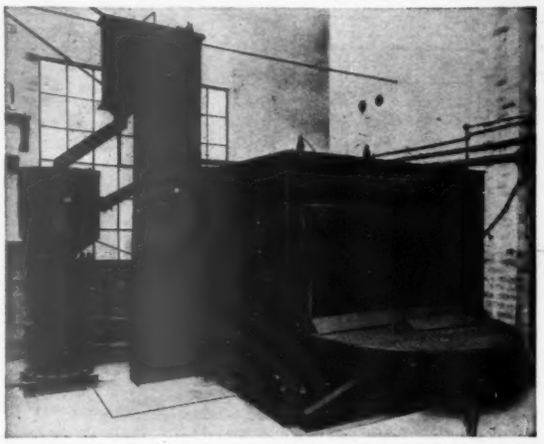

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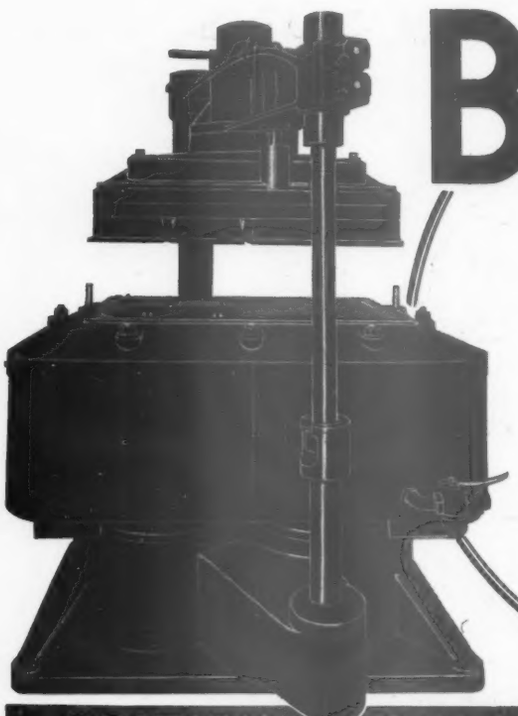

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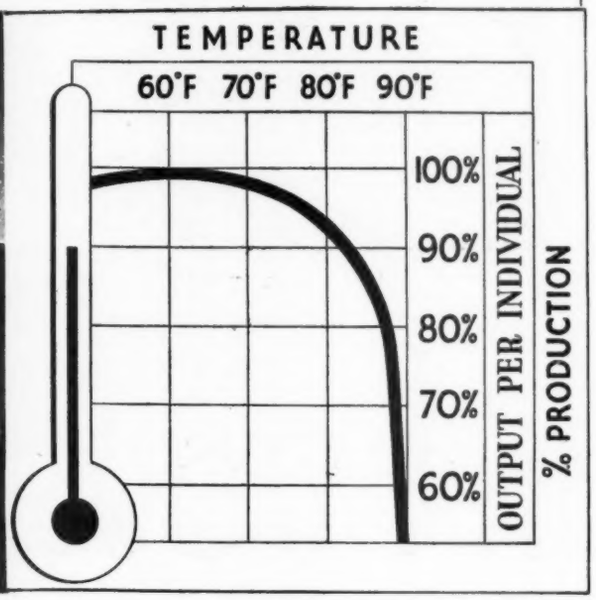

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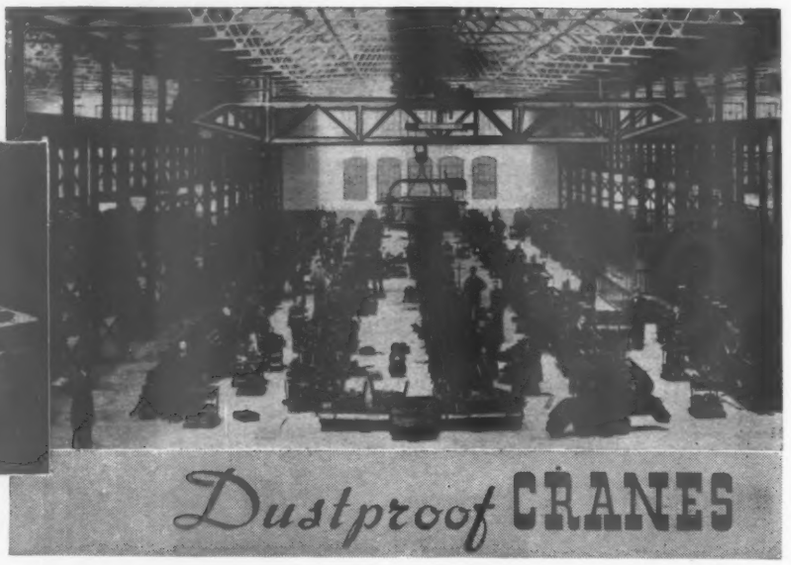

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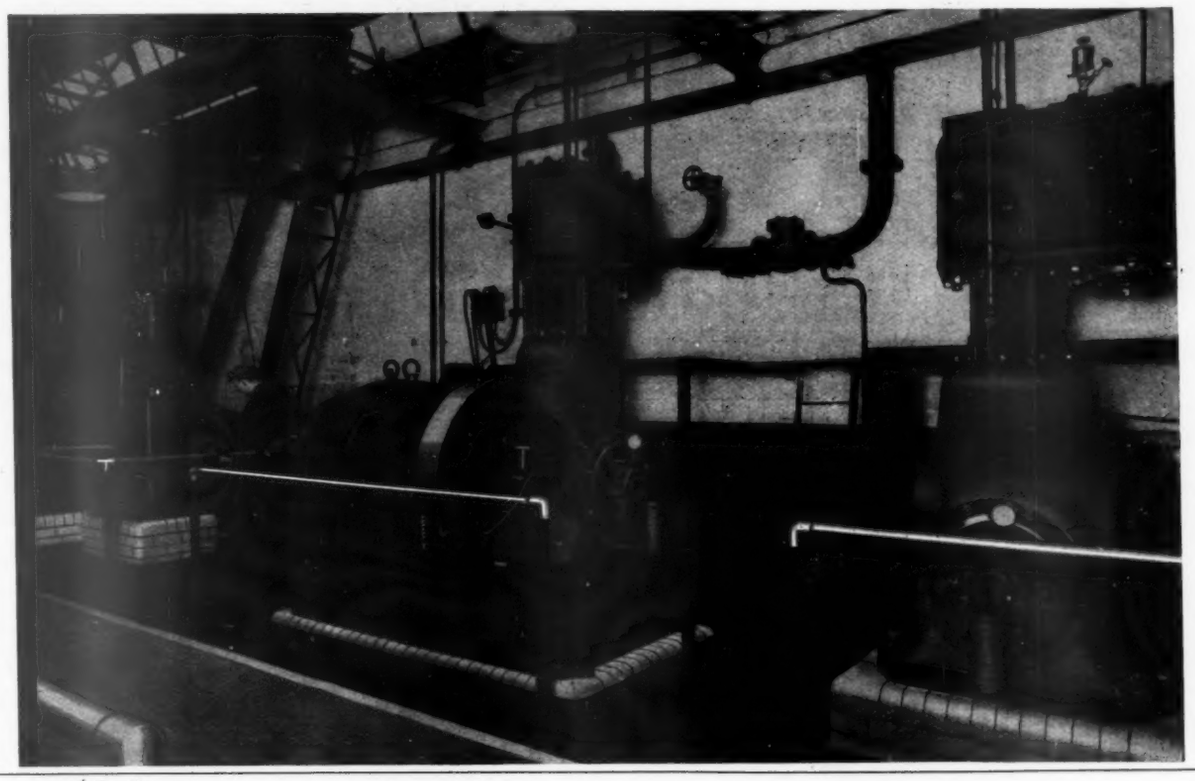

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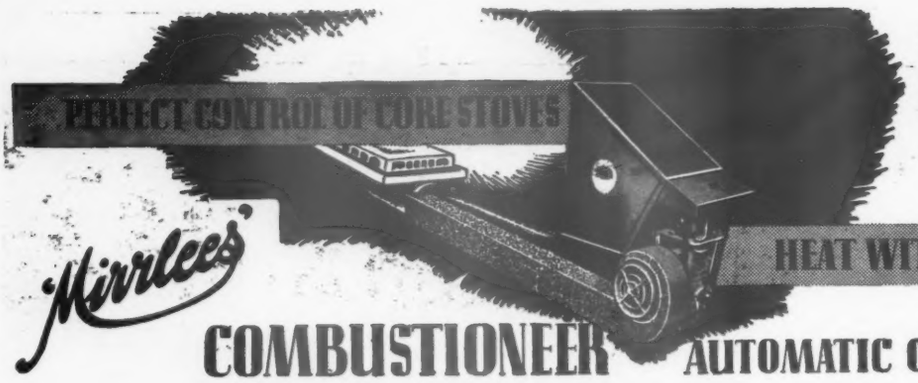

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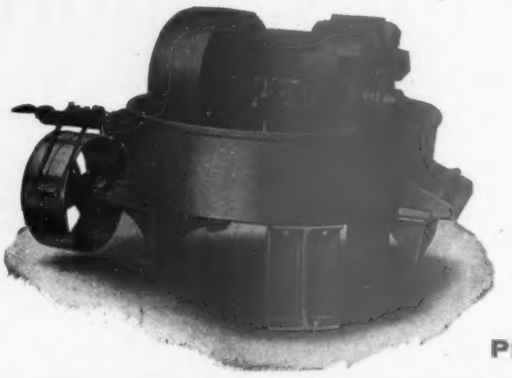

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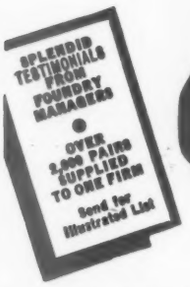

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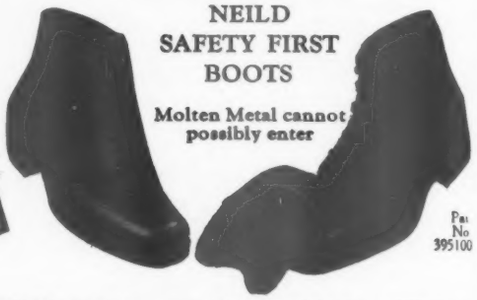

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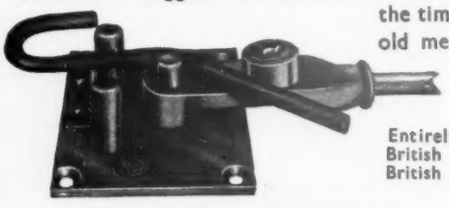

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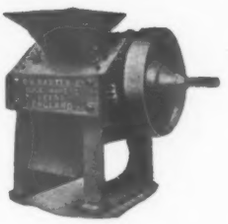

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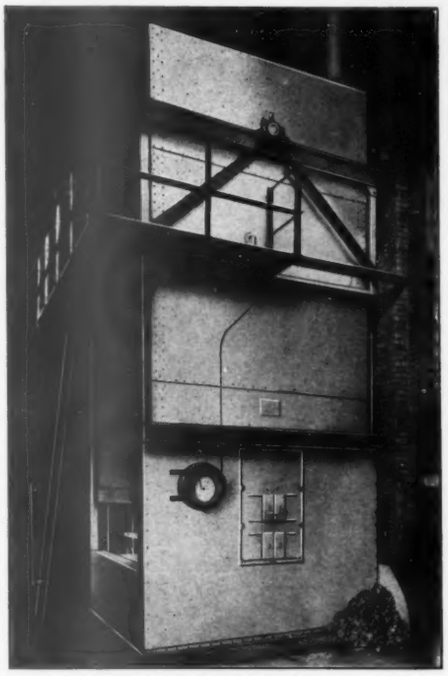

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